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UNDER THE EDITORSHIP OF **LEONARD CARMICHAEL**

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PHYSIOLOGY

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Contemporary Readings in General Psychology

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EDITOR'S INTRODUCTION

Nearly every student and teacher concerned with higher education must cope at one time or another with the unavoidable limitations of library reserve shelves. As one solution to this increasingly vexing problem, the present book has been assembled to provide in one convenient volume a carefully tested selection of modern and appropriate readings from a wide variety of sources for the beginning student of psychology. Its availability makes unnecessary the reserving of many duplicate copies of scores of books and periodicals. The readings are predominantly from recent publications, and the total book has a crisp freshness that is bound to appeal to the student.

The selections are intended to supply the college undergraduate who is starting his work in psychology with representative statements to supplement the information gained in lectures, class discussions, and textbook study. The readings are for the most part by scholars who are well known for their research contributions, but the material is never too technical for the first-year student. In the pages of this book the student will learn at first hand some of the answers that the masters of modern psychology give to the insistent problems of the field. Some of its selections also have a direct relevance to other college courses and to the problems that everyone meets as he lives in a modern world in which applied physical science is challenging old values and old modes of behavior. Certainly almost every student who owns this book will wish to keep it as part of his permanent library because it speaks in the idiom of this generation.

It is educationally sound to allow each person who studies even a single course in psychology to learn to read with understanding the general literature of the subject. In studying this book the student accomplishes this aim, for in its pages he comes in direct contact with the vocabularies and the styles of presentation of the eminent men who wrote the selections. To take but a single example, it is one thing to read about or hear a lecture on the experimental work and systematic position of Professor B. F. Skinner of Harvard, but it is educationally different and certainly also most worthwhile to read Skinner's own words in the treatment of an important topic in modern psychology.

Dr. Daniel has taken a number of years in preparing the present book. He has tested many of the readings in his own classes, and has discarded scores of selections which did not meet all of his criteria. The readings that he finally chose were selected because they are clearly written, intellectually stimulating, and above all because they are factually and scientifically important in what they have to say about present-day psychology.

Shoemakers' children do not always have good shoes, and psychologists do not always use the best psychological principles in teaching psychology. But in this book an experienced and successful college teacher has used what seems to the editor to be sound psychology in preparing a volume that is both educationally effective and academically attractive.

LEONARD CARMICHAEL, Secretary

Smithsonian Institution

PREFACE

The group of selections in this book has been chosen for the student taking his first college course in psychology. An effort has been made to balance articles on subjects in which students are interested with articles on subjects which their teachers consider to be important. This procedure has really not been so difficult, because much of the very best material satisfies both criteria.

Several other considerations have guided me in making this collection. First of all, I believe that there is an important difference between reporting scientific work and talking about it to an interested, intelligent friend. By reporting, I mean the sort of thing psychologists do for their professional and technical journals to communicate with each other. Such reports are detailed, impersonal, and sometimes even dull. In this volume my aim has been to find selections written by behavior scientists about their work — or by trained science writers after interviewing them — which are directed not to fellow scientists but to an audience of educated and "being educated" people, and I have tried to choose selections which would partially satisfy and partially challenge the intellectual curiosity of that audience.

Another aim was to select readings which could be organized around a limited number of the most important principles of behavior. It is unlikely that the student will remember many of the details about psychology for very long after he has finished his first course. But he should expect to master a limited number of basic concepts worth remembering and relating to the whole of science, culture, and his personal intellectual life.

For this book nine such principles or concepts have been selected as topics for the sections. Within each section there are a number of readings which support the principle suggested by the topic. Although not all psychologists would agree that these particular topics are the nine most important, I believe that they would be included in the top twelve or fifteen by almost everyone.

1. *Psychology is a scientific enterprise.* In any study of science it is important that the student understand the *scientific point of view.* The scientist's way of looking at the world of nature is characterized by intellectual curiosity, objectivity, and skepticism. Most scientists recognize that there are several approaches to knowledge — the philosophical, the religious, the artistic, and others — but hold to a strong conviction that the scientific approach can contribute to culture and civilization in a unique and valuable manner. Psychologists have often written about the difficulties of applying scientific methods to an understanding of human nature, but these very difficulties may teach us more about the scientific method than we are likely to learn from another science where the difficulties are not so apparent. The concept for Part 1, then, is that science offers a special kind of approach to nature and that human behavior is a vital part of natural events.

2. *Psychology is the science of the behavior of organisms.* This title closely approximates the definition of psychology in most modern textbooks, but it is not a dictionary definition nor the one most persons would think of. So it is really a new idea for many, and one full of rich implications. There are two key words here, *science* and *behavior.* Human nature has been studied throughout recorded history, but studied scientifically for less than a hundred years. By application of the powerful methods of science we have learned more about our own behavior in that short time than we had learned in thousands of years. There are still many puzzling problems for future research, but when we consider what was known, say, in 1850,

we realize that progress has been astonishing. Scientists in their different specialties study the behavior of something: chemists study the behavior of the elements; physicists study the behavior of light, electricity, objects in motion, and the like; biologists study the behavior of organs and organ systems in plants and animals; astronomers study the behavior of stellar bodies; and so on. Psychologists also are concerned with the understanding of behavior — that of man and animals.

3. *Behavior is adaptive.* Phrased another way, this principle says that behavior is modifiable. Such familiar terms as learning, memory, experience, and perception play a part in it. If there is one characteristic of human nature we are most certain about, it is that man can adjust to changing environmental conditions. Although man does not hold exclusive claim to this ability, he is superior to all other animals. From his biography of experience and his hereditary potential he makes meaningful the things he sees and hears. Throughout life he continues to accumulate experiences which build up to give him judgment, reason, ability to communicate, locomote, manipulate, and to control his environment, as well as to adjust to it.

4. *Behavior is variable.* This notion should be contrasted with the stereotyped or fixed nature of the behavior of mechanical devices, or, to a lesser degree, to that of simple organisms. The term variability applies to the behavior of one individual in different circumstances, and to that of several individuals in the same situation. We vary in every aspect of behavior and we vary along many different dimensions, but these variations are not disorganized or whimsical. They follow a predictable pattern which permits us to make probability statements about human behavior in the same manner (if not yet with the same precision) as in the other sciences.

5. *Behavior is developmental.* There are two implications in this principle. It refers to the development of behavior parallel to the growth of the individual (ontogenesis) and also the development of behavior from the simplest to the most complex organism (phylogenesis). Behavior does not just appear, it develops gradually. Both lines of investigation give a fuller understanding of the emergence of behavior patterns and the relationship of behavior to biological maturation, heredity, and environmental stimulation.

6. *Behavior is dynamic.* Psychologists put great stress on an understanding of behavior through the study of an individual's needs and his satisfaction of those needs. Looking at behavior in this way impressses us with its dynamics or self-directedness. Common terms such as motivation, drive, ambition, goal-striving, and many others are included in the concept. The great complexities of behavior become clearer when we begin to understand that man inherits and develops many needs and learns a great variety of ways to satisfy them. Sometimes these dynamics go awry, producing abnormal or pathological behavior, and these occasions provide us with another approach to understanding behavior. In this concept of behavior, perhaps more so than in any other, we see the very core of human nature.

7. *The behaving organism is biological.* Behavior does not exist apart from the individual, and he is fundamentally a biological creature. We must examine the functional properties of the organism which permit or limit behavior. Organisms can respond only to those environmental influences which they can perceive, and can perceive only from information supplied by the sense organs. All behavior must ultimately result in movement if it is to be useful, and this means activity of muscles. Between the sensing equipment and the action equipment of the organism there is a vast and complex interconnecting communication and integration network — the nervous system. Other organ systems influence behavior in varying degrees, but these three — sensory, nervous, and motor systems — have been most stressed in psychology because of their direct role in the response act.

8. *The behaving organism is social.* Among those environmental forces which shape our behavior, not the least in importance is other people. What we do, how we think, is partially determined by the behavior of others, whether we consider

them individually or collectively. Influences come from formal groups like the family or the school, from loosely formed groups, such as a community, or from such derivatives of groups as customs, laws, and institutional practices. Principles seven and eight are sometimes combined in the statement that psychology is a biosocial science. It is more appropriate to think of psychology as a behavioral science which studies significant influences in biological and social forces.

9. *Behavior can be controlled.* Not only do we seek to understand behavior as such, but we need to understand how it is controlled. Eventually we may wish to harness those controls for the ultimate good of man himself. Such a goal is indeed an ambitious one and progress involves the behavior scientist in a heavy responsibility of which he is fully aware. No one questions the control of disease; few question the control of natural resources for man's comfort, convenience, and safety; but control of the behavior of others involves us in ethical considerations which are of utmost importance. Greatest progress has been made in those areas where public opinion is strongly in favor of or not fundamentally opposed to such control. But psychologists are not unmindful of possibilities which lie in the future — the control of prejudice, of social stress, and of international aggression.

One further thought which guided me needs clarification because it is just hinted at in the paragraphs above. Not every reading in this book concerns psychology in the narrowest sense. Among the authors (or those written about) are philosophers, sociologists, anthropologists, biologists of various specializations, and other scientists, as well as psychologists. The breadth of the collection supports my conviction that psychology is a member of the whole family of sciences. Its next-of-kin are the social sciences on the one side and the biological sciences on the other. We are gradually adopting the term "behavioral sciences" to refer to those which are concerned with human behavior. Some psychologists like to think that their science sits at the head of the table in this little family because all of the questions for which it seeks answers are questions directly about behavior. Nevertheless, from the questions, the methods, the findings, and the point of view of our sister sciences come some really significant contributions to our ultimate goal — a better understanding of human nature.

I would like to add a brief statement about the relationship of this book of readings to your textbook. The latter is a survey of the science of psychology, whereas this reader is a sampling of certain problems arranged about the nine concepts described above. It provides more extensive coverage of these problems than your text author could achieve in the allowable space. Additional readings are suggested at the end of each section.

The student should not expect every selection in this book to represent the three objectives (nontechnical interpretation, illustration of basic principles, and treatment of psychology as a behavioral science) equally well. They vary in style of writing, in difficulty, and in appropriateness. Some give answers whereas others raise questions. Some are controversial and undoubtedly some contain inaccuracies or interpretations with which some psychologists will disagree. This situation is not only inevitable, but it is desirable. It is my hope that from these readings the student will be prompted to discuss and explore, because, in the words of James Thurber, "it is better to know some of the questions than all of the answers."

I wish to make public my thanks to the several consultants who made suggestions in the planning stages, especially to Dr. Robert Harper of Knox College, Dr. Carl Duncan of Northwestern University, and Dr. W. J. McKeachie of the University of Michigan. Responsibility for the final selections and the introductory paragraphs is not to be charged to them, however. Editors, publishers, and authors from whom I sought permissions were very kind and generous in making material available. Original sources are given with each selection.

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University of Missouri

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PART I

Psychology Is a Scientific Enterprise

THE IMAGE PSYCHOLOGISTS HAVE OF THEMSELVES AND THEIR WORK IS BEST SUMMARIZED in the official statement of purpose of the American Psychological Association. The society exists to advance psychology "as a science, as a profession, and as a means of promoting human welfare." These are not three unrelated aims; they are intimately related and interdependent, the first objective being basic to and prerequisite for the others. One cannot build a profession on opinion, prejudice, or even casual observation of human nature. A body of established facts, given meaning through the fabric of theory, is the foundation upon which the practice of psychology is established. Likewise, the hope of making contributions to human welfare, significant enough to take their place beside contributions of other kinds, is dependent upon a faith in the method of science.

So in this first part the reader will find some challenges which are faced by a science of human behavior, comparisons between this science and other sciences, and something about the scientist's point of departure in philosophical considerations. There is a word picture of the scientist as a human being (himself an object of scientific inquiry), a brief statement of how he works and thinks scientifically, and finally an introduction to the experimental method in science.

1

The Scientist in Our Unique Society

JAMES BRYANT CONANT

In this article, a distinguished physical scientist discusses some of the problems created by our search for knowledge versus our need to solve practical problems. He places psychology in the social sciences and takes a position about its role in society, an approach shared by many psychologists. Dr. Conant emphasizes the need for groups of scientists from different subject fields to work together for greater accomplishments, but he points out some significant difficulties and responsibilities.

The substance of this paper formed the address Dr. Conant delivered as outgoing president of the American Association for the Advancement of Science. It was published in the *Atlantic Monthly* of March, 1948 (pp. 47–50), and is reprinted by permission of the publisher and the author.

In the United States during the next few decades science may well play a determining role in the outcome of affairs. The same statement might be written today in London, Paris, or Moscow, making the appropriate national substitution for the words "the United States." Every industrialized nation is dependent on applied science for the continuing welfare of its economy and, alas, for the military security of its frontiers and cities. In my opinion, however, there is a special sense in which science is called upon to help with our national problems here in this country. Furthermore, it seems to me that a special group of sciences are involved. These are concerned with the study of man and, it may be noted, function differently in various nations, depending on the cultural pattern and the ideology. Physics and chemistry are the same on both sides of the alleged iron curtain; not so, social psychology or anthropology.

Some years ago I ventured to propose that the secular learned world might be conveniently trisected. Supporting myself as best I could by quoting Francis Bacon (and only slightly misrepresenting his point of view), I suggested that we should do well in this century to distinguish between (a) accumulative knowledge, (b) philosophy, and (c) poetry. The operational test to distinguish the first area from the other two is relatively simple and quite obvious. Whenever it can be said with some assurance that earlier writers or practitioners, if brought to life today, would recognize the superior position of their successors, then we can speak of accumulative knowledge. By such a test one distinguishes between Plato on the one hand and Archimedes on the other; or between Milton and Harvey, or between Kant and Newton.

Large portions of history and philology as well as all of archaeology fall under this definition of accumulative knowledge, as do the physical and biological sciences and mathematics (including symbolic logic); likewise our increasing knowledge of man as an individual and as a social animal, and all of the practical arts from mining through agriculture to government, are included — provided, of course, there has been real progress. This whole vast field may be called science if you choose, and the German word *Wissenschaft* is often used in just this way.

This broad use of the word "science," however, is apt to be confusing. The word "science" has very definite connotations for the layman. These are today connected with only one branch of accumulative knowledge. For that reason I suggest that we define science historically by equating it with the extraordinary activity which arose in Italy in the sixteenth century and spread to the rest of Europe in the seventeenth, and which in our time has flourished and proliferated with so much vigor. Around 1600 there was a change in point of view among learned men which was so marked as to be revolutionary. It was so regarded by the leaders of thought of the seventeenth century, who often spoke of the "new philosophy," meaning experimental and observational science.

I place science, therefore, within the area of accumulative knowledge. According to my view, only in very recent times did science emerge from the other human activities which had been accumulating knowledge for thousands of years. The characteristic of the new philosophy of the seventeenth century was that it sought to deal with those ideas or concepts which arise from controlled experiment or observation and in turn lead to further experiment or observation. Science, thus defined, is to be regarded as a series of interconnected conceptual schemes which arose originally from experimentation or careful observation and were fruitful of new experiments.

The test of a new concept is not only the economy and simplicity with which it can accommodate known observations, but its fruitfulness. Science has a dynamic quality when viewed not as a practical undertaking but as a process of developing conceptual schemes. Science advances not by the accumulation of new facts (a process which may even conceivably retard scientific progress) but by the continuous development of new and fruitful concepts.

The definition of science I have chosen, I should like to emphasize, is entirely independent of the field of inquiry or of any application of the knowledge obtained. Parallel with the development of science in the last three centuries and a half there has been a rapid development of the practical arts. At first the two activities were largely independent in spite of the hopes of Francis Bacon and the new philosophers. Improvements in the art of working metals, of growing food, of making glass and ceramic materials, and even in increasing the destructive power of weapons, were little affected by the early scientific work. It is not until we get into the nineteenth century that we begin to see anything like the practical influence of scientific progress to which the first scientists so confidently looked forward. And it is only in the twentieth century that we have seen so close an interaction between advance in science and progress in the practical arts as to result in some popular misunderstanding about the relation of the two.

SCIENCE AND THE PRACTICAL ARTS

It is as though we were dealing with a continuous spectrum. At one end we may place the changing conceptual schemes arising from experiment and giving rise to experiment (pure science, if you will); at the other end we place the improvements in the practical arts that have been going on for millennia. Not until about 1600 does the pure science end of the spectrum become visible. While this end increases in width and intensity for the next two hundred years, so likewise the opposite end continues to glow brightly. Then the intervening space narrows, and in our century the intermediate zone becomes full of glowing lines connecting the once totally disparate ends with each other.

The procedures of the scientist are now used daily to solve immediate problems which were once solely within the province of the skilled artisan. Though we can still recognize the two ends of the spectrum to which I referred, the intermediary zone now occupies the main position. For not only has pure science invaded the practical arts, but the practical arts have penetrated deeply into science. In many areas one cannot distinguish between the techniques of the scientist interested only in new conceptual schemes, and those of the experimenter interested only in an improved industrial machine or process.

If we turn our attention from the physical sciences to the biological we find a similar phenomenon. How difficult is it today to draw the line between pure and applied science in such fields as biochemistry, physiology, and even bacteriology. The application of new ideas and new tools developed by the physicist and chemist to the study of biological problems — the use of isotopes, for example — has been one of the most successful undertakings of the last three decades. Is this pure science or applied science? Who can say? Within each subdivision of the subject matter, one can recognize a whole spectrum of activities ranging from the search for a broad understanding of certain biological processes to immediate concern with a very specific case. Certainly the interplay between those pressing for solution of medical and agricultural problems and those concerned only with fundamental investigations is today very fruitful. There is no room for argument as to which is a superior activity. Neither the clinician nor the chemist can afford to look down his nose at the other fellow. They are too busy cooperating, the one with the other.

This was not always so. In the middle decades of the nineteenth century the cleavage between scientists and practitioners was much greater than in our time. This was so both in the physical and in the biological sciences. Clerk Maxwell's public comments on Alexander Graham Bell's telephone are a case in point. The physicist reviewing the inventor's work left no doubt in the audience's mind who was top dog in any hierarchy that mattered. Even Pasteur could be regarded as a promising young chemist gone astray.

The pendulum has now swung very far to the other side — too far, some scientists would say. Today investigations concerned with disease rather than with basic concepts in biology are apt to receive popular acclaim and, what is more important, large financial backing. Is there danger that in the present fusion of pure and applied science the tradition of the investigator interested *only* in the conceptual schemes will be so weakened as to disappear? I am inclined to think so. And if this happens in any country, the effectiveness of the application of the physical and biological sciences to practical problems will soon diminish greatly. History shows that only by a continuous development of pure science can the practical arts, including medicine, advance.

SPECIAL NEEDS OF OUR UNIQUE SOCIETY

Up to this point I have indicated how significant is science for *any* modern industrialized nation. Now I should like to consider the special situation of the United States.

According to my view the society that has been developed in this country is unique. It is similar to other democracies in many respects, but because of our special history we have certain ideals that are a product of our past. Our solidarity as a nation depends on our acceptance of these ideals and a concerted effort to move continuously toward the social goals implied. But this is no easy matter.

The complexities of modern society are great. For the future welfare of the society, we require the services of a group of able scientists whose numbers now are few. These men in turn need to have developed very rapidly new tools and new concepts, for at present the degree of empiricism in their endeavors is far too high. Unfortunately the group of sciences I have in mind, unlike physics or chemistry or the classical aspects of biology, have no long record of success behind them, viewed either as a dynamic development of conceptual schemes or as aids to practically-minded men. Nonetheless, I am convinced that this is the strategic time to stimulate and encourage these endeavors. Specifically, certain types of work in sociology, anthropology, and social psychology seem full of promise. The point of view of the younger men in these fields (and I emphasize the adjective "younger") indicates that the time is now at hand when rapid advances will be forthcoming, and from these advances will flow practical consequences of great value to this nation.

It would seem obvious that the best minds of the country should be devoted to a study of the many problems arising as a consequence of our endeavors to keep our society prosperous, strong, and democratic. It is my belief that methods have already been developed to a point where studies of society by competent scholars can provide basic information to assist all those practical men who struggle with the group of problems we list under the head of human relations. Both fundamental investigations as to the nature of man and society and immediate studies of specific problems are required. The cooperation between medical men and psychologists and psychiatrists should be strengthened. While I am emphasizing the sciences of psychology, anthropology, and sociology, I assume that the newer approaches to many of man's individual emotional problems will involve the physiological as well as the psychological approach. It is at this point that I believe certain of the younger sciences and the younger scientists may play a determining role in assuring a vigorous development of this unique society of free men.

My confidence in what may be accomplished flows from my assumption that advances in the science of man and society will go hand in hand with fruitful applications of the techniques and concepts now available. Relatively few people realize how much progress has been made in the last decade and what techniques are now at hand to assist in the solution of practical problems. But it is the future which is exciting, for I imagine that even the most enthusiastic psychologist or anthropologist would readily admit that at the present moment the conceptual schemes at their disposal are the equivalent of what chemists and physicists had in the late eighteenth century. As a consequence, in every case of the practical application of the sciences concerned with human behavior the degree of empiricism is very high.

As in the medical sciences in recent years, many of the practitioners should be the very ones to advance the science. If a chemist may be bold enough to give advice to younger colleagues in a far-distant field, I would say the life of Pasteur affords a relevant analogy. As a scientist and as a practitioner he solved immediate problems and likewise increased our degree of understanding in those branches of biology he made his own. Do not be misled by the divorce of theory and practice which characterized the work of Newton, Clerk Maxwell, and even Darwin. There are times and places when even the purest science cannot make progress in the ivory tower. On the other hand, one may express the hope that the ultimate consumer, the general public and the practical men, will not press too strongly for immediate results. Projects concerned with applying the knowledge now at hand must not be so numerous or exacting as to prevent a sturdy effort to decrease the degree of empiricism in the methods now in use. In short, the long-range as well as the short-range programs require adequate support.

VALUE JUDGMENTS IN CERTAIN SCIENCES

The statement is often made that science is neutral so far as value judgments are concerned. This is one of those three-quarter truths fully as dangerous as half truths. Let us consider the medical sciences today. Investigators and practitioners concerned with human disease almost unconsciously accept a set of values which limit their activity on the one hand and on the other serve as powerful spurs to their endeavors. This fact seems to be overlooked when the neutrality of science is proclaimed. Much more than the Hippocratic oath is involved. Only in a society where life is considered preferable to death and where health is glorified would funds flow freely for the study of disease. Only where the sanctity of each individual is so strongly felt that it is regarded as a paramount duty to save every life possible at whatever cost would physicians, surgeons, and medical scientists act as they do today. Our standard of medical care and our desire to raise it are based on a series of value judgments. Let me make it plain, I am not questioning the assumptions. I am merely pointing to the existence of these postulates basic to all work in the medical sciences. I do so because I believe that the situation is analogous in the case of those scientists who are investigating human behavior and human relations but that the analogy has not yet been fully realized.

The assumptions of the medical men and their allies are by now fairly well accepted in modern industrialized nations, though in practice the value placed on human life certainly is subject to wide variations. The assumptions essential for the proper functioning of the psychologist, anthropologist, and sociologist in our unique society, however, are, I believe, as special as the history of this society itself. The equivalent of the Hippocratic oath which these men might well subscribe to would therefore be related closely to the type of society in which they propose to operate. The English and the American versions even might vary at several points but the essentials would be the same. Totalitarian nations, on the contrary, would use the techniques developed by these scientists for very different ends; and their use would condition the further advancement of the sciences themselves. Powerful tools are in the process of being forged by the scientists who study man as a social animal. These tools can be used to further or to destroy certain types of behavior and certain social patterns. Therefore, it is essential for the men themselves to clarify in their own minds their own standards of value.

A study of the writings of the last fifty years makes it evident that the myth of the neutrality of science has been used as a smoke screen for reactionaries and radicals alike. For example, within recent times some who have wished to see a tight class structure develop in the United States have analyzed society in so-called scientific terms. Likewise those who have wished for a socialistic state have been able to quote the results of modern investigators of society for their own ends. My objection to these procedures stems less from my lack of enthusiasm for the objectives than from the failure of the authors to be explicit as to their premises. Gunnar Myrdal has faced this question squarely and said, "There is no other device for excluding biases in social science than to face the valuations and to introduce them as explicitly stated, specific and sufficiently concretized value premises."

I am inclined to think that to forward their own work as scientists and practitioners those concerned with the sciences of man might well join together and issue a proclamation. Or if that is too much to hope for, recognizing the importance of rugged independence among learned men, at least as individuals each one might make his position clear. Of course, it is for the men in question to formulate their own Hippocratic oath. Nevertheless, to illustrate what I have in mind, I venture certain suggestions.

THE POSTULATES OF OUR UNIQUE SOCIETY

I believe a very large majority of the citizens of this country would be willing to subscribe to a common set of postulates as to what we desire to accomplish in the coming years. The goals of equality of opportunity, a minimum of class distinction, a maximum degree of individual freedom, and a wide distribution of centers of initiative are inherent in the American tradition. Would not all of us be happy if we felt certain that a decade hence the United States would be appreciably nearer those historic goals? So it seems to me. Therefore, the set of social ideals corresponding to these goals might form the basis of agreement among the scientists in question. All concerned with medical science, however objective and neutral they may claim to be, are urged forward by a desire to improve the public health and a firm conviction they will do so. Likewise, the scientist concerned with human relations and the structure of society must have conviction as to the aim of the practitioners in his field and a belief in the possibility of accomplishing at least some of the objectives they have in mind.

I have drawn a parallel between the application of modern science to the ancient art of healing and the application of certain sciences (still young) to the likewise ancient art of counseling human beings as to how to live and work together. If there be any merit in my analogy, the reason why I spoke of basic differences in these sciences between totalitarian countries and our own needs no elaboration. Biochemists, physiologists, and pharmacologists would either be out of place or enlisted in strange services in a society which deemed it essential to eliminate by death all infants except the physically robust, all the sick and wounded, and all above the age of sixty. While admittedly no modern nation has these aims, they are the logical projection of the Nazi philosophy.

Without belaboring the difference between the study of man and society here or, let us say, in Rumania, I should like to explain in more detail why I think our unique society has special need at this moment for the scientist in question.

THE PROBLEMS AHEAD

The United States, unlike almost any other country, has not arisen from a state founded on military conquest. Therefore, we have nowhere in our tradition the notion of an aristocracy entitled to rule by right of birth. Run through the other democratic nations of the world and, if you recall their history, you will see how striking is our exceptional origin and growth. Neither political nor economic nor social privilege comes to one by right of birth according to our American ideals. On the contrary, the members of each new generation are supposed to start from scratch. Merit alone should win. Cynics may shrug their shoulders and say this is theory — the facts of modern American life are far different, and likely always to remain so.

We must admit that sneers of this sort expressed by men who pride themselves on being hard-boiled realists are sometimes heard. Those who express such ideas fail to realize that in an open society ideals are goals. Almost by definition they never can be realized in practice. But we can recognize whether we are moving toward them or retreating. The ideal of equality sums up much of the uniqueness of American society to which I have referred already. This ideal, coupled with our adherence to the principles embodied in the Bill of Rights and our inherent belief in fair play and tolerance, makes a pattern which many of us have in mind when we use such phrases as the American creed. In spite of the vast discrepancy between those ideals and the facts of life, I am convinced that we are not a nation of hypocrites. But unless we can demonstrate by collective action that we are making progress toward the goals implicit in our ideological pattern, we shall have difficulty maintaining the solidarity of the country. For the morale of a nation, no less than that of any group of men or women, depends on agreement as to the ends for which all labor.

But it is no simple matter to move appreciably toward the goals in question — the historic goals of our unique society. Industrialization as well as size presents us with problems of terrifying complexity, not to mention the unfavorable posture of world affairs. Our economy is based on private ownership and the profit motive; we desire to keep this economy flexible, with as many competing units as modern industrialization permits, and with as much independence as possible for both management and labor. Yet there are few who advocate today the old doctrine of "hands off" private enterprise. The complexities of modern society have made the public a party to what once seemed a strictly private matter. The machinery of government is today meshed into our industrial life. The problem is to see how we can operate our private enterprises and our political institutions so that our society will be in fact competitive and thereby increasingly productive.

Grave problems of fundamental policy confront us as a nation at this moment; they will continue through the coming years. I have no illusion that basic national issues can be handled by any group of scientists the way problems of design of bridges and machines can be treated by engineers. Nor do I believe that in the near future many policy questions which must be resolved by governmental officials, business executives, or labor leaders can be handed over to scientists to find an answer which is "right." Most of the decisions must be made on the basis of experience coupled with the advice of competent analysts and those whom I have ventured to call social philosophers. The point of view of the scientists may be of assistance in these matters and the results of their investigations should be of increasing value. But the types of problems where one can hope for immediate assistance from the social psychologist, sociologist, and anthropologist are for the most part somewhat limited in their scope; they involve human relations and those tensions among individuals and groups which have been so much intensified by the conditions of modern life.

The need for reducing these tensions as part of the process of improving and humanizing industry is evident. What is less well understood is the applicability of the newer points of view to planning public education and providing that our secondary schools will serve the welfare of the community. In short, policy-makers in government, business, labor, and education must be increasingly aware of the assistance they can receive from those who study man and society as scientists.

Let me illustrate by a brief consideration of our public schools; they are a concrete manifestation of our belief in the idea of equality of opportunity. We believe they should be ladders by which youth with varied talents may reach satisfying employment, with everyone entitled to a fair chance. Every year some two or three million youth mature, leave school or college, and look for jobs. Unless each year this annual crop of youngsters can be fitted into our economy, we shall fail to keep our society prosperous and dynamic. Therefore, our educational system must be heavily involved in the whole question of guidance and of placement. The specific problems will vary from city to city, from state to state. Here is a case where we are beginning to have sound knowledge and can look forward with considerable assurance to further improvements in the methods. Here is a case where the welfare of the nation depends on our skill in solving a whole host of human problems.

I could go on and list similar instances concerned with education, group relations, social organization, and personal adjustment to show how in our society we have special need for a vastly improved science of man. The empiricism of the past may be a sufficient guide for the masters of a police state, but an open society with our ideals requires other instruments and a wider understanding of modern man. We should be wise to expect no miracles and not to harass ourselves or the scientists by shrill cries for speed. My crystal ball yields me no secrets as to the future of the world. Conceivably we may all be blown up by atomic bombs within the next few years, as some of my colleagues seem to think. Their reasons for this dire prediction, however, appear to me to be quite inadequate. I prefer the contrary assumption. I have faith that we shall be wise enough to escape a global war. I likewise believe that we shall move forward to still greater strength and prosperity as a democracy, and that the morale of the nation will continually improve as we demonstrate that our American ideals are no mere myths or legends. And in this all-important undertaking, I have confidence that the skill and wisdom of the scientists cooperating with practitioners will play an important part.

2

The Parallel Roles of Physical and Social Science

DOUGLAS E. SCATES

Like the preceding article, this selection treats the study of human behavior as social science. Professor Scates draws attention to the fact that there are limitations in the control of human behavior, just as there are limitations in the control of physical forces, and in both cases there are persons involved in control other than the scientists who learn how to do it. In discussing the interrelationship of basic and applied problems he shows the importance of both, and how they share a common objective in values held to be important for mankind. In a letter to the editor of this reader, Dr. Scates stated that he very much favors the application of research to the problem of social values, although some critics of his article have had the impression that he does not.

Professor Scates is a member of the faculty of the College of Education at Duke University. His article is reprinted from the January, 1947, issue of *Scientific Monthly* (pp. 14–20), by permission of the publisher and the author.

In these times when the values of science are being actively considered and issues are raised as between the service of social and physical science, it is appropriate to seek some perspective on the work which is being done. If we are to contribute to, rather than delay, the "trend toward system and unity in the scientific enterprise as a whole" we cannot afford to magnify distinguishing differences. We must look for some general purpose in the joint endeavor of scientists. Strange symbols and esoteric details often keep one area of science from becoming familiar to workers in another area. Can we not find common ground by overlooking technicalities and turning to larger aspects?

The effort to see social science in perspective is made difficult by the fact that we are all so close to it. And, again, the study of man and his relations, pursued in the manner of science rather than in the manner of individual judgment and ready prescription, has not been under way sufficiently long for its approach to prevail widely. There is a strong tendency to view the entire field in personal, commonsense terms. One is likely to ask, "What is individual behavior more than volition, and what are social problems more than differences of interest? Is not the heart of the matter that of getting people to be less selfish in their living and more cosmopolitan in their outlook?" Perhaps; but does such a general conception direct attention to the possibilities of scientific insight? Does it provide suitable guides for scientific effort? Familiarity with outward aspects does not guarantee understanding of inward relations.

In parallel fashion one might ask, "What is physics more than the study of the relationships and movements of units, large and small? Is not the heart of the problem that of getting things to move as we desire them to?" Possibly; but from a statement of this nature one might conclude that physics was given mainly to such commonplace matters as how to drive nails or knock croquet balls about. Simple conceptions do not encompass the horizons of scientific endeavor, nor do they establish its basic character. The sophistication of mature thought is not comprehended in sketchy verbalisms.

It is important to ask whether a particular conception of a field is conducive to the development of science on the level of basic principles or on the level of engineering applications. Is there some danger that we, as scientists, shall insist that physical science be thought of in terms of systematic abstractions and at the same time conceive of social science in terms of purely practical attempts? To do so is to contribute to the continued poverty of social understanding and to deny to social science the discharge of its main duty. For one does not approach an area solely in terms of immediate, practical considerations and come out with science. In all fields of understanding there is the necessity for a framework of theory as a basis for more concrete forms of application, and it is to the gradual development of this frame of thought that fundamental effort in any science must primarily be dedicated.

The development and testing of theory carry us beyond the level of everyday observation and interpretation. So long as one looks at society in terms of personal problems he will see only personal problems in society; when one views society with scientific interest he will observe in man's behavior significant generalities. Basically, it is the social scientist's purpose to find in social phenomena those underlying uniformities which can be integrated into a thought structure that is capable of abstract manipulation and is reasonably accurate in predicting consequences. By virtue of these properties this science should be effective in affording man some control over the world of social events. It is the social scientist's conviction that by studying man and his behavior scientifically he will eventually be able to offer society not only a coherent system of ideas about man, but a consistent set of principles which can be utilized by man for his own betterment.

What problems will social science solve? Will it undertake to remake human nature? Will it stop wars? Purge society of crime? Eliminate poverty? For perspective we can turn to the field of physical science. Does man try to change the course of the planets? Does he counsel the seasons? Do his deliberations level the tides? The answer is that man does what he reasonably can. He adapts nature to his advantage where feasible and adapts his habits to nature where necessary. Thus he stores the rain in reservoirs, but builds houses, wears clothes to temper the effects of weather. He seeks to manage in part where he cannot command in full. Without serious thought of checking the continuous rise and fall of coastlines he dredges harbors and raises dikes. In the field of human relations we can expect man to do the same sorts of things he does in the field of physical relations. The social scientist cannot remake basic human traits, but he can modify and redirect them. He can aid man in making more satisfying and efficient adaptations and, as his scientific knowledge increases, he can develop new forms of control over social conditions and forces.

How, in practical terms, are such things to be done? For example, how will social science settle conflicts of interest from which so many social difficulties spring? Will science forsake its long tradition of impartiality and take sides? Will it make the strong stronger and the weak weaker? Will it prepare for one side lessons in the art of docile living while tendering to the other techniques of domination? The answer must be that immediate action is the province of the administrator and the practical worker, not of the researcher or the designer. The social scientist, in studying the forces of society, will take note of those which oppose each other, but he will not expect to build science by deciding disputes. He may participate in practical affairs as a form of personal service and as a matter of maintaining an orientation, but vocationally his are not the functions of the legislator, the administrator, the jurist, or the moralist. The world's work has many divisions with differing responsibilities. The scientist's service is real even if it be several steps removed.

In the physical field, man has learned to utilize much of science for his advantage. We may therefore turn to technology for further ideas on how to put knowledge to work. Physical science has not eliminated opposed forces either in equilibriums or in "opposite and equal reactions"; and we cannot expect to eradicate them, in either static or dynamic form, from the social scene. But through technical applications of science man does hope to deal with forces, whether physical or social, before they reach critical proportions, and his goal is to arrange conditions so that forces will expend themselves in contributing to the common good instead of wasting in useless heat or dissipating in wanton destruction. The purpose of science, practically, is to provide principles by which such ends can be achieved.

Applications of physical science have given us factories, railroads, airplanes, radios, mechanical refrigerators, and so on. These things are possible because means have been found for transforming and channeling energy so that it behaves within limits which man expects and regards as desirable. Man builds machines which utilize force and carefully direct it. Thus the combustion in the cylinder of a gasoline motor does not wreck engine and operator because the energy is confined by adequate forces and masses opposed to it, and the force generated is largely directed toward the work to be done. Technology, rooted in principles of science, consists essentially in prearranging responding parts and inertial masses so that force will serve man's will.

The social scientist thinks of social machinery in the same fashion. For every phase of scientific knowledge and application in the physical field there is a counterpart in the realm of society. Social forces, no less than physical forces, have their methods of generation, their mediums of transmission, and their appropriate machinery for translation into effective results. Anyone who doubts the reality of social force must of necessity doubt the reality of war, and anyone inclined to question the actuality of social machinery must question the existence of government. The commonly observed conflicts of interest in the field of society are no different in their general outline from the contrary forces in the physical world or the universal competition in the biological world. The problem in any case is one of studying the kinds of machinery which are effective and efficient in transforming, conveying, and utilizing force.

The skeptical may insist, "Show me these social machines. Let me examine their parts. I must have concreteness." Does one ask to see shafts and pulleys in the universe? Does he question whether objects fall because he can see no lever to push them down? Are we to doubt that light and gravity traverse empty space because we know of no medium which conducts them? Social machines are common patterns wrought in the minds of men. They exist largely as conventions, sometimes written, more often not. They may be laws, they may be traditions, they may be newly accepted practices. In essence, they are attitudes, habits, and expectancies — mind sets which generate, guide, and limit action. But we need not be concerned here with substance. That is the province of the social scientist; the point of general interest is that conditions can be arranged in society so that force is channeled and regularized.

To avoid a world of chaos all of us want adequate social machinery, and we want competent administrators prepared to operate it. We want the aggregate energy of mankind to express itself within generally acceptable limits and be directed toward the accomplishment of ends which are both socially and individually beneficial. It is theoretically possible to design social machinery having various degrees of immediate efficiency — to waste different amounts of the social energy in "heat," "friction," and "lost motion." It is possible to set the design so that the tolerance limits for satisfactory results are very narrow, as in totalitarian states, or very broad, as in a democracy. It is possible through design to establish high or low factors of dependability, stability, or safety. In short, with increasing scientific knowledge and within the limits of compatible characteristics, any kind of social machinery that is desired can be arranged.

One may be tempted to ask, "Then why don't the social scientists design an ideal machine and stop all the inefficiency and turmoil in the social world?" One might as well ask, "Why don't the engineers in the automotive field give us a motor which obtains all the value of the fuel, loses no energy in wasted heat, has no internal load, does not get out of order, and will not be superseded by something better?" Our wishes must not mislead our judgment. We live in a practical world, a world of conflicting values and necessary compromises, both social and physical. There is not now and never will be any perfect form of gasoline motor, or of social life. For that which is ideal in some respects is achieved by sacrifices elsewhere; and that which has been attained is soon thought ordinary, denying satisfaction for long. In the dreams of tomorrow the goals of today are forgotten. Knowledge advances, interests shift, desires expand. Under the impetus of changing conditions and perspectives designs also must change. Science knows no rest. Continued effort fashions constantly improved offerings, but never the ultimate.

With respect to getting his knowledge and insights incorporated into practice, the social scientist is in much the same position as the designing or consulting engineer. Neither one can set up what he regards as the most desirable model and then say, "Here is what the world should have; take it." Save for their professional writing both work at the bidding of others and within limits set by others. The scientist characteristically and almost necessarily looks at his problems in fairly narrow terms; society has found it practicable to set up other groups (administrators and legislators) to look at problems in broader terms and to interpret more widely the desires of people. So the designer of some phase of a new model of an automobile is told to work out his design within the limits of certain over-all specifications decided on by a planning board, most of whose members are not engineers at all. Likewise the social scientist who works out a new form of government, or perhaps a model city plan, will probably not find it of any use to do so unless he has been requested by an administrator or a policy-forming group to assist them, and unless they have laid down the general limits within which his study and recommendations are to fall. When engineers are members of policy-forming groups they have a better opportunity to advance their particular views; but the social engineer is not free to "run" society any more than a designing engineer "runs" an industry. Scientists are frequently disappointed; but beyond the beliefs and recommendations of specialists lie the judgments of the great body of people who, theoretically and practically, are the ones to be satisfied.

There are other parallels between physical and social science which should be noted. Perhaps the one of largest interest concerns the presumed normative character of social study. One not infrequently finds among his friends a tendency to think of the events of the world as falling into two classes, those which are in the domain of science and those which are covered by morals. There is a tendency further to identify physical things with science and social affairs with morals. Such an attitude grows out of man's long background of thinking about human action primarily from the moral point of view; he may not realize that behavior can also be looked at from many other frames of reference. Hence, even among some physical scientists, there is a strong belief that the chief character of social science is normative, that is, that it exists to determine what people *ought* to do. Much of what has just been said bears on the point: Society has given to groups other than physical and social scientists the function of interpreting its current wants and deciding what should be done. But the question as usually conceived goes deeper: Is there not something beyond immediate wants? Are there no fundamentals in man's existence? Does the social scientist not have anything more to offer society than machines? Can he give no advice as to the ends for which machines are to be used?

The first answer to these questions is, No. The fact that, as individuals, we recognize a strong need for definitive answers in the area of large purposes and ideals is not warrant for assuming that science is the appropriate medium for providing those answers. We must always give heed to the fine line between science and philosophy. The first obligation of science is to view the world of things as they are. This view is normative only in the sense that it is descriptive. Social science is concerned with the same kind of aspects in the social world that physical science is in the physical world. One is not immediately any more moral than the other. The problems of weighing the findings of scientific work and weaving them, along with other considerations, into a suitable picture of the ends for which man should hope and the purposes for which he should live are the responsibility chiefly of philosophy and of religion.

But the second answer to the questions is a qualified Yes. Man's basic interest in the world does not stop with a description of statics; man seeks as well a description of natural processes, of changes which regularly follow certain patterns. The second obligation of science, therefore, is to deal with the world as a system of interactions — a world of cause and consequence. The mature scientist sees the static aspects of nature as but phases of a dynamic universe. Accordingly, the social scientist, in studying manifold social sequences, has the duty of studying those which involve various goals and various intermediate values. When man lives according to certain specified ideologies, what happens? Does he progress toward the goals he hoped for? What do different patterns of living lead to?

The social scientist does not seek to prescribe the ultimate; science finds no answers for basic teleology. That is an area for individual interpretation and group choice. But science can hope to identify those proximate ends which tend toward certain ultimate purposes, and it can in turn describe the general effect on society of holding various philosophies. Science has no traffic with notions of inherent rightness, but it has a basic interest in discovering what results follow the acceptance of particular orientations. To this end the social scientists will gather data over long periods of human experience and from the varied practices of widely dispersed societies. He will describe, analyze, and relate. Like the physical scientist, he will seek to sift the essential from the nonessential among the conditions which produce certain results. Without presumption to moral finality, his findings will give breadth and perspective to the thinking of philosophers and to the plans of statesmen.

As for those who may fear that the social scientist, after prolonged study, will decide how man should live, and dictate the ends he should accept for his existence, they may refer to the relation between science and philosophy or religion. Certainly physical science narrows the range within which man's reasoning is unrestricted; but does it not still leave large opportunity for man's yearning to go beyond scientific facts and build pictures which quicken his daily effort, strengthen his high resolve, and encourage his trust that in ethics there is something enduring? Social science will restrict and refine man's notions about what is good, but it will not take from man his right to think, to interpret, and to decide. Social science affords a mirror for man's behavior and a telescope for his judgment, but man's ultimate choice is his own. Society determines its course, with such counsel as it may take, through the instrumentality of the machinery it elects.

The reality of values cannot be doubted. There are ends for which each individual hopes and there are goals toward which he strives. Values relate his activities to these large ends. They are as real as the tropisms of biology or the "pulls" in any field of science. We may not understand why a tree grows vertically but we do not therefore ignore or deny the tendency. One might as well demand a science of physics without gravity, or a science of chemistry without valence, as a science of man without values. They are part of the scheme of attractions which move mankind as planets and particles are moved. The full nature of the causes which make all things move — the nature of energy, of life, of psychological response — is perhaps as much a basic mystery in one field of science as another. Science studies what it finds means of studying. We must concede actualities whether or not we can resolve them.

But values are not absolute; they are not ultimate, they are instrumental. They are connecting links between statuses and purposes. They inhere in the relationships between properties and large designs, relating the means to the end. We may draw an analogy from the physical world by asking, "What is the value of air?" The respondent may point out that air is necessary to support life, though it does not guarantee life. It affords temperature moderations, else we should have the extreme heat and cold of the moon and all life would disappear. It carries water vapor, supporting the hydrologic cycle and permitting terrestrial life. It transmits sound. It supports aircraft but is an impediment to rockets. It turns windmills and sails ships; it produces storms and destroys. It is generally impure; it often contains smoke, sulfur dioxide, and noxious gases. It carries dusts, soot, bacteria, viruses, pollens, and fungi, giving rise to many ills. What is the value of air? Specific properties become utilities when related to purposes. Values, scientifically, are these utilities.

Given certain ends, the industrial engineer can say that certain materials and processes are necessary in order to achieve them. We hope that the social scientist or social engineer may be able to draw on his pure principles to render the same sort of service. He will be acquainted with the basic psychological needs of mankind — the essentials without which a society cannot be stable and maintain a long-time existence. He will know what values are called for in order that certain more distant ends espoused by a civilization may be approached. He will recognize that certain goals are incompatible with others. He should be able to outline what consequences may be expected when certain values are increased, reduced, or altered.

And, while pursuing these practical activities of helping society solve its problems, he will probably find opportunity to develop his basic science still further. Has not pure chemistry profited from research connected with the very practical problems of producing better electric lamps, or polyamides for manufacturing nylon?

Science arises wherever man turns his attention with intent to observe, describe, relate, and synthesize. In both physical and social science the fundamental object is the study of force — its generation, its behavior under the influence of various factors, its effective control through the arrangement of other adequate forces and masses, and ultimately its appropriate channeling so that it will serve ends chosen in advance by man. These ends then become a part of the cause-effect sequence which must be understood in designing and operating physical or social machinery. The social scientist may wish with the physical scientist that the affairs of man were conducted on a higher plane; but he takes human nature and human behavior as the physical scientist takes physical nature and physical behavior. It is their duty to study and describe and to offer their findings for the service of mankind. It is not ground for criticism, however, if either one works with the thought that his developing insights may eventually bear fruit in making a better world.

The advance of science lies along a broad avenue, theoretical on one side, practical on the other. We must honor workers who find their chief interest principally along one side or the other of this avenue. There must be theory; there must be applications. What the ideal proportion is cannot be stated. Pure science must synthesize and provide an interpretation for the numerous practical studies; it must delve into areas which only the theorist immediately cares about; it must be the fountain from which many new applications become possible. But basic science is not the most common nor the most conspicuous form. The ratio of expenditures for applied research to expenditures for pure research is about six to one in this country, not counting war research. If social science seems at times to be characterized by nearness to practical problems, does it not find a stimulating precedent in physical science?

It is not fitting to close without pausing for recognition of the underlying motives of the true scientist. His work is so little understood that it deserves frequent appreciation. Behind and beyond all thoughtful modes of adaptation lies the scientific spirit. This spirit is not entirely separate from man's wants, for it dwells in man; but neither is it to be identified wholly with practical affairs, for it transcends the bounds of necessity and exceeds the stress of immediacy. It may be called man's curiosity at work; in truth it is more than that. It is the steady conquest by intellectual force of the mysteries of nature. It is the reconstruction in comprehensible terms of a universe which, in its original form, is largely incomprehensible. Science is man's most daring response to the challenge of the vast unknown. It is an expression of his willingness fearlessly to face truth. If in our several labors we have effected something of a division of effort, can it be said that research workers are less able to satisfy their deep desire to understand and appreciate nature when engaged in the study of man than when engaged in the study of masses?

3

Science and Its Presuppositions

A. CORNELIUS BENJAMIN

Since all sciences are related to philosophy, it is appropriate that we consider this relationship. Dr. Benjamin examines the beliefs which lie behind the scientific enterprise and clarifies their proper relationship to scientific work itself. He believes that the scientist's concern about basic assumptions is related to the depth and significance of his contributions to intellectual progress.

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It is commonly recognized that the most significant difference between philosophy, on the one hand, and the more specialized studies, such as science, art, religion, education, and politics, on the other, is that philosophy is concerned with the critical examination of certain concepts and beliefs that are presupposed by these more specialized studies. For example, the average scientist readily admits that, although his study is based upon certain beliefs in the uniformity of nature, the rationality of the world, and the relative attainability of truth, he is not himself, as a scientist, called upon to subject these notions to critical examination. He can argue either that such justification is not ordinarily required for the actual carrying on of science, or that *if* such justification is demanded it can readily be provided by the philosopher whose job is, by common consent, precisely the examination of the assumed notions of science. Similar considerations apply to art, religion, education, politics, and the other specialized studies. Thus there have arisen, particularly in recent years, philosophical disciplines, such as the philosophy of science, the philosophy of art, and the philosophy of education, whose assigned tasks have been the disclosure and critical examination of the unconscious beliefs and assumptions held by the scientists, the artists, and the educators.

There is reason to believe that this fundamental distinction between the task of the philosopher and that of the specialized investigator is essentially correct. But there is an unpleasant air of obscurity surrounding the entire problem. This need not be too disquieting for the latter group, since their task, as suggested above, does not include the consideration of these issues. But it is disturbing for the philosopher, both because his job *does* include the examination of unconscious assumptions, and because he is obliged in all frankness to admit that he has not, up to the present at least, succeeded either in making clear what is meant by "presuppositions" and "assumptions," or in laying bare the actual presupposed beliefs of any one of the specialized studies.

I should like to contribute what I can to solving the problem by attempting to eliminate some of the sources of obscurity. In order to keep the discussion at the concrete level, I shall confine myself to the question of the presuppositions of the sciences rather than of the arts, religion, politics, or education. Since essentially the same considerations apply wherever the question of presuppositions arises, the conclusions will not be unduly restricted by this limitation.

WHAT DOES THE SCIENTIST BELIEVE?

When one approaches the problem empirically and asks practicing scientists what assumptions are involved in their procedures, he is likely to receive answers that are fundamentally the same, though the diversity in emphasis and in formulation may suggest greater disagreement than is really the case. The common element is usually expressed in terms of a belief in the rationality of nature, or in the adequacy of the scientific method as an instrument for exploring the world, or in the (at least relative) attainability of truth. Thus there seems to be present, at least implicitly, in the minds of most scientists a conviction that the task in which they are engaged is capable of yielding a certain measure of success, and is in some important sense worth while. Whether the goal of science is identified with theoretical understanding, or merely with an improvement in the health and well-being of mankind, is not for the moment important. What is significant is that the ideal, however formulated, is judged to be most effectively attained by the existing method, together with such improvement as may be introduced in the years to come, and is sufficiently important to warrant the sacrifices that must be made in trying to reach it.

The sources of apparent disagreement in the statements of presupposed beliefs lie in the fact that some philosophically minded scientists are not content to let the issue rest at this point. They wish to determine in some more basic way the conditions that would have to be met by the world, by the scientist, and by his method, if the scientific goal is to be attained. In this attempt certain scientists emphasize the criteria which must be satisfied by nature herself — objectivity, uniformity, simplicity, etc. A common form of this solution, which runs from Pythagoras to Sir James Jeans, is that the fundamental stuff of the world is mathematical in character. Others call attention to the scientist — his unemotionality and freedom from prejudice, and the accuracy and caution he uses in the employment of his method. Still others believe that the primary assumptions concern the method he is using — the validity of the laws of logic, and the adequacy of his criteria of clarity and confirmability. In all these cases scientists are attempting to make somewhat clearer than is ordinarily the case the basic assumption as to a kind of rapport between the scientist and nature. It would appear that the two participants in the cognitive enterprise have entered into an unconscious agreement that each will endeavor to do his part toward the ultimate attainment of knowledge.

Just what role, then, do these beliefs about nature, the scientist, and his method play in science? The common answer is that they are "presupposed." But what is meant by this term? The suggestion of some sort of *priority* seems to be involved, and one is immediately led to ask whether it is *temporal* priority or *logical* priority.

The absurdity of supposing that the beliefs are *temporally* prior to science becomes apparent at once. To grant this would imply that the scientist, before really beginning his scientific activity, sits down and makes a thorough study not only of the scientific method itself but also of the kind of man he must be to carry on science and the kind of world we must inhabit if it is to be knowable by scientific techniques. This is contradicted by the obvious fact that the average scientist simply does not do this. To be sure, he must have, prior to science, a kind of rudimentary knowledge of what the method is and how to use it. But no serious person would claim that he must refrain from using it, or from committing himself to the scientific enterprise, until he has assured himself of the truth of all that this involves in the way of beliefs about nature, himself, and his method. The more or less obvious fact is that most scientists begin by just "doing science." They may, in certain unusual cases, train under a good teacher who occasionally calls their attention to certain principles of method which they are using; they may, in still rarer cases, take courses in logic and scientific method as part of their scientific education. But information of this kind, although contributing to greater clarity in the grasp of the scientific method, is employed mainly to develop skills, and does not make any serious claim to justify the scientific method, or show why it "works," or to indicate what elements of "rationality" nature must contain if the method is to produce results. These fundamental problems are raised, if at all, only much later, and their solution is deemed to be of no significance to the scientific enterprise itself.

One seems led to the conclusion, therefore, that such beliefs, if temporally prior to science, must be unconsciously or only implicitly present; the scientist has such beliefs, but he doesn't know that he has them; the beliefs are "there," but the scientist cannot find them, both because they are so nebulous and because he finds it impossible to say what he means by "there." The result, in any case, is completely unsatisfactory; if the beliefs cannot be found, and if there is no empirical evidence for their existence, we might just as well deny them completely and eliminate the problem at one stroke.

There is, however, an alternative. Perhaps the beliefs are not temporally prior to science, but logically prior. According to this interpretation, the beliefs need not actually occur in advance of science, but they are the *necessary condition* for science; i.e., if they were false science could not go on. But this runs up against the stubborn fact that many scientists — good as well as bad — never think about these issues at all, even posterior to science. Yet the ability of such individuals to practice science and to produce results seems to be in no serious way affected. Even if one were to force the issue by asking these scientists whether they do not feel the need for such beliefs, or how they would attempt to justify them *if* the need for them could be demonstrated, he might well receive a very disappointing reply. He might be told that the entire problem is purely academic, since the healthy fact seems to be that science "works," and all such beliefs are pale and anemic by comparison. Perhaps some scientists would be willing to concede that the beliefs, if shown to be necessary, could be accepted on "faith," or could be shown to be purely arbitrary postulates, or might even be shown to be "intuitively" true. But in any case commitment to them would involve no serious violation of one's intellectual honesty, since the evidence for or against them would be too vague and uncertain to be decisive.

This reaction of scientists to the problem suggests that the issue has not yet been made sufficiently clear. Undoubtedly there *is* some sense in which the scientist does take for granted certain facts about nature, himself, and his method. One has only to formulate the problem negatively to see that this is the case. Suppose, for example, a scientist were convinced not only that nature changed in some fundamental way overnight, but that the *way* in which this change took place could never be detected. The result would be that his knowledge would not carry over from one day to the next, and he would have to start anew each morning. Or suppose a scientist were convinced that man could never think rationally — that prejudice, emotionality, wishful thinking, and the like prevailed in his reasoning processes to such an extent that he could place no reliance whatever on his results. Such an assumption would have to involve something more than the generally recognized fact that these factors *do* play a role, somewhat larger than we are always willing to admit, in our thinking processes; it would have to commit us to the belief that in spite of the recognition of these pitfalls, in spite of training in objective thinking, and in spite of clear-cut knowledge of the principles of the scientific method and the most extreme caution in their use, our unconscious desires and motives, hidden prejudices, and unavoidable preconceptions would make forever impossible a rational view of nature. Or suppose, finally — to exaggerate a difficulty that has recently been disclosed by quantum mechanics — the scientist believed that whenever he observed anything the very process of observing changed the object in unknowable ways. He could then have only a post-mortem knowledge of nature, i.e., a knowledge of nature as it manifests itself to the observer, but not as it is "in itself." Science, in the usual sense, would then be impossible.

One might reply that these are all hypothetical cases, and no scientist really believes any such absurdities. But this in no way invalidates the results. On the contrary, the fact that no scientist has accepted any such beliefs — which would be extremely difficult to establish on empirical grounds — may itself be of the greatest significance. Perhaps scientists have recognized the inconsistency that would be involved in the continued pursuit of science *if* they held such beliefs; perhaps they have been too devoted to their task, and have had too strong a faith in their methods, to yield any place to beliefs that would make their enterprise absurd. Perhaps the absence of such beliefs is itself evidence of the fact that we all indulge in wishful thinking. But the point remains. Certain beliefs do seem to be incompatible with the pursuit of science. Hence, even if we cannot conclude that there are beliefs that are logically presupposed by science, we can infer that there are certain other beliefs of a negative character which, if held by scientists, would tend to discourage the continuation of their task and might even induce them to give it up entirely.

When we ask, therefore, whether there are any beliefs that are necessarily presupposed by science, the answer seems to be that such beliefs are not properly required for the *carrying on* of science, but that they are needed for its *justification*. This basic distinction between acting and justifying one's actions runs through the entire gamut of human behavior. One may act morally without at the moment being able to state the principle directing his actions, or one may enjoy a painting without at the time being able to formulate the aesthetic criterion at the basis of his appreciation. Similarly, one may pursue truth without being able either to define truth or to state what conditions must be satisfied by nature and by man if truth is to be attained. Reference to conscious standards is dispensable at times both because man has developed habits that are adequate in many complicated situations, and because he seems to be endowed with certain intuitive capacities that enable him frequently to make correct judgments without knowing how he has done so. In terms of our problem this means that science may, for relatively long periods of time, and through unexpected vicissitudes, go on its merry way without requiring any examination of presuppositions or assumptions; furthermore, science seems, in general, to be none the worse for this fact. In this sense there are no beliefs that are presupposed by science, and the insistence on the part of certain philosophers that the scientist must uncover and make peace with his presuppositions seems somewhat misplaced. He can justifiably reply that science has been doing very well, thank you, without this kind of inquiry, and the prospects seems not too bad for the future.

THE BROADER NEED FOR JUSTIFICATION

But there are two reasons why this restricted view of science — or, for that matter, of art, religion, morality, education, or any of the other special studies — cannot be satisfactory in the long run. In the first place, situations are almost certain to arise, sooner or later, when habits and hunches no longer prove adequate. Critical reflection then becomes obligatory. Frequently these are cases in which science suffers a "shock." Examples abound in the history of science, particularly in the past century. One need mention only the discovery of non-Euclidean geometry, the negative outcome of the Michelson-Morley experiment, and the discovery of the principle of complementarity in quantum mechanics. These were all cases in which science, for the moment at least, trembled at its very foundations, and re-examination of basic concepts and presuppositions became imperative. Other situations which force the examination of assumptions occur when the scientist suffers repeated defeat, and avoids utter despair and disillusionment only by a reconsideration both of the ideals he has set for himself and of the faith he has placed in them. It is characteristic of most of the goals of life that they are accepted uncritically so long as they prove adequate, and are called up for examination only when they fail to do the job expected of them.

In the second place, one must recognize that there are individuals, scientists and philosophers alike, who seem to be provided with an unusual allotment of intellectual curiosity and will simply not remain content so long as this borderline area of assumed notions and unexamined concepts remains unexplored. They are the intellectual gadflies of science who destroy our complacency by continually asking "Why?" For them science as a going affair is essentially an invitation to indulge in this kind of speculation. They will not be satisfied with the simple statement that science "works"; for this, they point out, involves a general pragmatic principle that whatever works is to that extent justified, and why should we accept *this* principle? They will not remain content with the claim that the scientific method represents the most effective use of our reasoning powers yet developed and thus is the most adequate method for obtaining truth; for this simply invites the double-barreled inquiry: Why should we be reasonable, and is truth worth its salt?

The point is not that these questions must be answered if science is to receive ultimate justification; probably many of them cannot be answered at all. Bertrand Russell has shown that the principle of the uniformity of nature, which is at the basis of all induction, cannot itself be proved inductively; but, since it cannot be proved deductively, it cannot be known in any way to apply to nature. Probably also the objectivity of nature cannot be proved in any final manner, since all proof is essentially subjective. The questions are asked not in order that answers may be forthcoming, but in the hope that the issues which led to the asking of them may be clarified. The precise formulation of a question, even when the answer cannot be given, often contributes to better understanding.

The general conclusion, therefore, seems to be that when the scientist acknowledges having certain presupposed beliefs concerning nature, himself, and his method he does not mean that he has any conscious or clear-cut notions to which he has definitely committed himself, nor does he mean that the beliefs are required in any important sense for the continuation of science. What he does mean is that if these beliefs could be shown to be false, science would lose its justification. Hence whether or not a scientist has such beliefs, and the degree to which they are conscious and well defined, depend upon the need he feels for some grounding of his enterprise other than that involved in its continued working. If he is disturbed by some of the shocks science has suffered in the past by virtue of inadequate attention to its method; if he is more impressed with his failures than with his successes and thus finds himself concerned about the limitations of the scientific method as an instrument for exploring the world; or if he is one of those intellectually curious individuals who continually search for deeper and deeper foundations — in any one of these cases he will consider the examination of presuppositions to be an important part of his task as a scientist.

Probably it would be inaccurate to say that the scientist who pays no attention to these matters is the gadgeteer and pebble-picker who is so often held up for ridicule. On the other hand, it would be fair, I think, to say that to the degree to which a scientist shows concern for the presuppositions of his subject and for its interrelations with other areas of experience, he exhibits that broader understanding which transforms science as specialized knowledge into science as an important enterprise of the human spirit.

4

What Makes the Scientific Mind Scientific?

ANNE ROE

Dr. Roe's studies of creative scientists have contributed to our understanding of what is required to conserve one of our priceless natural resources — the inquiring mind. In this summary article she gives us a glimpse of the scientific man. He has unchained curiosity, rare initiative, high intelligence, a passion for freedom, and an unusual devotion to work. Whereas Dr. Scates in selection 2 compared physics with psychology, Dr. Roe compares physicists with psychologists. She also points out that although IQ's may be equivalent, patterns of intelligence differ markedly. Notice that the scientist profits from unknowns, ambiguities, and inconsistencies which he observes in nature. You may want to compare this characteristic of the scientist with the description of the college student given by Dr. Jacob in selection 38.

Dr. Roe has a distinguished career in psychological service and research. She was a Guggenheim Fellow in 1952–1953 and is now Chief of the Psychology Training Unit of the FDR VA Hospital in Montrose, New York. The description she gives below of the scientist first appeared in the *New York Times Magazine* for February 1, 1953 (pp. 10 and 22), and is reprinted here by permission of the publisher and the author.

Man's accelerating progress in unlocking the doors to nature's mysteries has put a premium on scientific brains. As a discoverer of new horizons the scientist plays a crucial role in today's world. He and his works are in great demand.

Because so much depends on scientists and because the true scientist needs certain favorable conditions if he is to do his best work, it is important to examine the scientific mind and to know what are its characteristics. What qualities mark the scientific mind? How and to what extent does it differ from the minds of lawyers, writers, business men and others? How does the scientist do his job? These questions are answered, at least in part, by a study made of sixty-four of our most eminent research scientists.

It should be noted at the start that there are no descriptive words that can be used about scientists that will apply to all scientists or will not also apply to some people who are not scientists. The same is true if you compare special kinds of scientists, such as physicists with anthropologists, or psychologists with chemists. This is natural enough, because scientists are also human beings. Nevertheless, there are some things which are more characteristic of scientists and of particular kinds of scientists than they are of other groups. The study, I should add, dealt primarily with the top, first-rate scientists whose creative efforts are largely in the field of pure research, rather than with those scientific workers whose jobs chiefly involve routines of applied research.

Consider, first, the scientist's attitude toward his work, for this furnishes a basic clue to the make-up of the scientific mind. There is a popular impression that outstanding scientists are likely to be absent-minded, rather shy geniuses who live in an abstruse world of their own, far removed from everyday realities. This is not necessarily so, yet there is an element of truth — and a very important one — in the picture. The element is the scientist's absorption in his work, which often seems to set him apart from other people.

CURIOSITY AND DEVOTION

The most distinctive thing about a first-class scientist is that he is completely wrapped up in science; he eats it and sleeps it. The chances are that he works nights and Sundays and goes on vacation only at his family's insistence. That is because he would rather be doing his work than anything else. He is not, it is true, unique in this respect; most men who go to the top in any field are devoted to their jobs. But the scientist, more than most, finds in his work the mental and emotional rewards which should and can produce the greatest results and the greatest personal satisfactions.

These satisfactions stem from two qualities of the scientific mind. One is curiosity. The other is an ability to work out solutions objectively and gain new knowledge independently and in the scientist's own way. Scientists, above all, are people who have retained a childlike curiosity, which many of us lose as we grow up. They have wanted very much to find out about things and have learned that within certain limits they can, little by little, discover what they want to know. Moreover, they have learned that they can find out things *for themselves* — not by asking someone else or by looking it up in a book (granting that it could be learned that way, which is often impossible) but instead, thinking for themselves.

The research scientist, working in a university or research institute, selects his own problems and goes at them in his own way. No one tells him what to do or when. He must, and wants to, find out for himself. Even when he was in school he preferred the teacher who stimulated him, or simply permitted him to work out the answers by himself, to the teacher who told him what to do each day. The need to become master of himself and his immediate environment is part of man's biological make-up. The scientist is one who has been fortunate enough to find a vocation which meets this need, for the gaining of knowledge is in itself a form of mastery, and deeply satisfying. Thus, the success of the scientist's work depends to an exceptional degree on his curiosity, love of the job and personal initiative.

INTELLIGENCE

Scientists, as might be expected, are a very intelligent group of people, whether you judge by intelligence tests or by what they actually do. Mentally, they are all above the average, and some of them are very, very high in the scale indeed. In my opinion, it is necessary, if a person is to become a good scientist, to have an I.Q. of at least 120 or more, and, other things being equal, the higher the I.Q. the better the scientist, if the intelligence is properly used.

I employed a special intelligence test in my study of eminent scientists (the usual ones are not difficult enough) which had separate parts for the different abilities we call verbal, spatial and mathematical — that is, for understanding of words, for ability to imagine the manipulation of objects in space and for ability to work out mathematical problems. I kept the tests separate because these abilities are not necessarily related; one may have very high verbal ability yet not be very good at mathematics, or vice versa.

The average I.Q.'s of this group approximated 165 for the verbal test, 135 for the spatial test and 155 for the mathematical, and they ranged from around 125 to nearly 200, or just about as high as you can get. There are, of course, other people with high I.Q.'s who do not become scientists. After all, the average I.Q. is 100, and about 10 per cent of our population have I.Q.'s as high as 120 or more.

There were interesting differences among different kinds of scientists as to the sort of test they were best at. For example, experimental physicists are likely to be relatively better at manipulating objects in space than they were at understanding words. Theoretical physicists were terrific at both. (I did not give the physicists the mathematical test; I could not get one that would be difficult enough for them that the others could do at all.) Experimental psychologists, geneticists and biochemists also tended to be better at the mathematical and spatial tests than at the verbal.

Botanists, anthropologists and clinical and social psychologists, on the other hand, were likely to be better at the verbal test than at the others. For instance, there was an experimental physicist with a verbal-test result somewhat lower than the average of the total group, but with the highest of all in the spatial test. The biologist with the second highest score on the verbal test was below the group's average on both spatial and mathematical tests.

PERSONALITY

It was also possible to give these eminent scientists some personality tests. These showed that they tended to generalize more than the population at large and to look for unusual aspects of things. Again, there were differences among the different groups. The natural scientists seemed to show a very considerable independence of the need for close personal relations, but quite the contrary was true of the social scientists. In none of these groups are the individuals very aggressive, though the social scientists are the most likely to be. This, however, does not mean that the scientists can be pushed around. Far from it. They are, on the whole, a stubborn lot, but they are usually too busy with their own concerns to interfere with other people's affairs.

BACKGROUND

In their life histories certain situations are common among them, but not unique to scientists. To judge by these samples, scientists tend to come from middle-class homes and to have fathers who were professional men, but particularly to come from homes in which learning is valued for its own sake as well as for the perquisites it may bring economically and socially. A large proportion of these first-rate scientists were first-born children, or at least oldest sons. The records indicate that the natural scientists as a group had tended to be somewhat isolated as boys, not to have been members of gangs and not to have had much social life. In contrast, the social scientists tended to have been leaders in student activities in college, interested in literature and to have had active social lives from an early age.

Many had an early interest in the things that later became their vocations, though some did not. A number of the latter appear to have lacked this interest because when they were young they did not realize the possibility of making a living at such things as theoretical physics or genetics or psychology, or if they had heard of such professions it was without any suspicion that they themselves could enter them.

This assessment of the characteristics of the true scientist now brings us to the question: Under what circumstances does the scientific mind do its best work? It is evident that one of the most important elements in scientific work is the special freedom it gives its devotees to use their excellent minds to master knowledge in their own fashion. But if science offers this special freedom, it also requires special freedoms from and for the scientist.

No one can go far in science if he is not free to see things as they are. The man who is burdened by political or any other ideologies that restrict his thinking — whether they are accepted by him or imposed on him by society — is not free to examine the world to see if it is really in accordance with his beliefs. Men have not always and everywhere been free to become scientists. Creative productivity, not only in science but also in art and other fields, has varied greatly from culture to culture and from age to age in the same culture. From the periods and circumstances under which productivity has been high, it seems clear that an essential factor in any culture where creative activity flourishes is a high degree of independence and individual freedom.

A very few scientists work best under moderate pressure, a number work best under a little pressure (such as wanting to finish an experiment in time to report it at a particular scientific meeting), but most of them do their best work when pressures are at a minimum, and particularly when they are not emotionally disturbed by problems outside of their work. Moreover, they need time — often long periods of time — in which they may appear not to be working at all, for scientific progress requires a lot of almost unconscious thinking. This is essential before most major advances, and it is the sort of thing that is difficult for non-scientists, such as some administrators, to understand and make provision for.

It would seem obvious that major advances in science are not made under the sort of working conditions that characterize the usual industry or government setup, with its precise assignment of duties and timing of them. In considering this, the distinction between science and technology — that is, between basic or pure science and applied science — must be kept clearly in mind. Most scientists working in industry or government are engaged primarily in the latter, which does not have the same requirements or the same satisfactions as pure science.

What happens when a research scientist tries to work "under orders" depends largely upon the working conditions and the man's real interest in the problem that falls to him. It is of course difficult for a trained research scientist who through his whole professional life has pursued the particular research that is of personal interest to him, and has done it in his own way, to alter his working habits suddenly and completely. This may eliminate the most important and satisfying aspect of his profession. Nevertheless, he may get along very well if he can become personally absorbed in the new problem and if the outside pressure is not too great.

But if he took on the job chiefly for the extra money or for some reason not important to him, it is likely that soon the lack of primary satisfactions will overbalance the immediate returns. Scientists and their families are not averse to having money, but usually other things are more important to them.

For the scientist, accustomed to talking and writing freely about his interests, government jobs with high secrecy requirements are especially difficult. Working conditions on some new government projects seem to have been specified by enemies, so perfectly are they designed to afford the maximum of frustration and minimum of emotional comfort to the scientist.

The wonder is that such extraordinary advances in pure science have been made under these conditions. The explanation probably is that the men at the top became thoroughly absorbed in the work or that they were sufficiently patriotic to drive themselves to do it even at considerable emotional cost.

Often the greater material freedom in the research itself has been a compensating factor; where no expense is spared for equipment and tools, the scientist can work on problems he could not possibly have touched before. But if he could not, even so, come to feel that they were his own problems, then research has faltered, or the man has quit or broken under the strain.

Given the qualities of the scientific mind — the driving curiosity, the personal approach to an enjoyment of the work, the high intelligence, the necessity for freedom — if the best creative faculties are to be used — it follows that management policies should be such as to cause a minimum of frustration to the scientific researcher. Enlightened management policies that give the scientist as much choice as possible in selecting his problem, that will make it possible for him to work in his own way and at his own time, and that are sensible in regard to security measures, would be a help.

Scientists do not regiment easily; they are stubborn and independent, and they have little patience with restrictions that seem to them unnecessary if not irrational. It is up to management and workers in other fields to realize these things about the scientific mind and make provision for them. In that way the nation can secure the best from its scientific brains.

5

How Scientists Work and Think

JOEL H. HILDEBRAND

A physical scientist here discusses the traits he considers to be the most significant for a scientist and how they contribute, through his work, to the improvement of our standard of living and to our intellectual environment. He draws an interesting contrast between the skepticism of the scientist and the uncritical acceptance of things which often characterizes the nonscientist (and sometimes the scientist, too, when he leaves his own laboratory).

Dr. Hildebrand is professor emeritus of chemistry at the University of California in Berkeley and is past president of the American Chemical Society. The ideas expressed in summary form below were included in a university lecture. This abridgment originally appeared in the Office of Naval Research, *Research Reviews* for February, 1956 (pp. 33–34), and is reprinted by permission of the Office of Naval Research.

The ways by which scientists have learned, through a gradual evolution, to form sound judgments are exerting great influence on human affairs. This influence would become far wider and more beneficial, however, if these scientific methods could play a greater role in the education of everybody, including scientists themselves.

Let us consider a few examples. When Lenin stated that, "Politics is a structure erected upon an economic foundation," he was using a pure analogy, having no value whatever as proof. Plato's assumption that heavenly bodies move in circles because "the circle is the most perfect geometrical figure" may have been pretty good for Plato, but we have learned in the meantime that the stars are not governed by man's notions of perfection. A scientist knows that "the law of averages" does not influence the weather to strive to follow a dry year with a wet one. He distinguishes between events which are predictable, like the death rate, and those that are not, like the death of an individual. He should know that it is not scientific to expect that the stock market will either fall or continue to rise simply because it has been rising, and, similarly, that the prediction of a "historicist" that "some sort or other of totalitarianism is inevitable" is a quite unwarranted extrapolation.

No mathematician now defines an axiom as "a self-evident truth," and no intelligent scientist accepts a conclusion based upon the assertion, "it stands to reason . . ." He knows that the value of a battery additive is not determined by the testimony of satisfied users (the method of lawyers) and that getting well after taking an alleged remedy is not proof that the medicine caused the cure. He knows that foaming is not the proper measure of detergency; that advertising claims of "better," "faster," "bigger," are meaningless. He is aware of the danger of oversimplifying, and likely to be skeptical regarding such simple models as "the economic man," "the average citizen," "the typical Englishman," and of the simple solutions offered by politicians for complex national problems.

Our people would profit by a much larger infusion of scientific thinking into their personal and collective life.

Science is not a lot of book-learning; it is an active enterprise. It is what scientists do and how they do it. They do not wave magic wands, neither do they proceed by a series of rigid logical steps to sure conclusions. Instead, they keep their eyes open for discrepancies between actual phenomena and the current explanations for them, and they try to improve them in order better to understand, control, and predict. They devise instruments for observation and measurement.

They use imagination to set up hypotheses, which they test by carefully designed and controlled experiments. Results found to occur so uniformly as to have high probability of recurrence are formulated as "laws," although it is understood that, unlike statute laws, they do not control. These laws are explained, where possible, by theories and models. Mathematics often plays an important role, but its limitations must be kept in mind.

A science develops beyond the initial stages of observing, naming, and classifying, by aid of unifying ideas or concepts, such as energy, entropy, quantum theory, and organic evolution.

The rich rewards of these methods in terms of economic prosperity and the health and well-being of the people are fairly well appreciated; what is not realized are their profound effects upon the ways in which we form judgments in general. Science is the great antidote to superstition, prejudice, wishful and emotional thinking. Its findings have, therefore, great influence upon social and ethical evaluations. It refutes, for example, the myth of racial superiority, responsible for so much of the world's injustice and cruelty. In the words of the philosopher, William R. Dennes, "Of all the servants of morality, science is the greatest; for it is the one serious way we have to discover what means are likeliest to lead to the realization of the ends we cherish."

6

The More or Less Scientific Method

RUDOLF FLESCH

All aspects of psychology benefit from objective investigations which begin with intellectual labor. The most powerful and fruitful method of scientific investigation yet devised is the experiment. Rudolf Flesch tells in the following article something about how experiments originate and why scientists conduct them. His contrasts between the popular notion of science and the image scientists have of their own work are particularly important.

Dr. Flesch received his PhD degree from Columbia University. His research on readability has had wide influence in applied psychology and education. This selection is from one of his best-seller books, *The Art of Clear Thinking*, Harper, 1951 (Chapter 15), copyright, 1951, by Rudolf Flesch, and is reprinted by permission of the publisher and the author.

Perhaps the most famous incident in the history of science occurred in the third century B.C. in Syracuse, Sicily. The mathematician Archimedes was taking a bath. His mind was busy with a scientific problem. King Hiero of Syracuse had ordered a golden crown and suspected the goldsmith of having cheated him by using some silver instead of the gold he'd been supplied with. The king had asked Archimedes to prove it.

Suddenly Archimedes noticed that his body caused some water to spill over. In a flash he realized the solution of the problem: he'd take the crown's weight in pure gold, dip it into water, and see whether the overflow was the same as that of the crown. Whereupon he jumped out of the tub, ran home naked as he was, and shouted to everyone he met: "Eureka! Eureka! . . . I've found it! I've found it!"

Perhaps the least famous incident in the history of science occurred in the twentieth century A.D.

in the United States. The chemist J. E. Teeple was taking a bath. His mind was busy with a scientific problem. He stepped out of his bath, reached for a towel, dried himself, shaved, took another bath, stepped out of it, reached for a towel and discovered that the towel was wet. Thinking about his scientific problem, he had taken two baths. He had not found the solution to his problem.

The first of these incidents has been retold a million times; the second is trivial. Nevertheless, the second is the one that gives the truer picture of the scientific method.

In the first place, the story about Archimedes puts the spotlight on the happy discovery, giving the impression that this sort of thing is typical of a scientist's life. Actually, "Eureka!" moments are few and far between. Einstein once said: "I think and think, for months, for years, ninety-nine times the conclusion is false. The hundredth time I am right." And that's Einstein, the greatest scientific genius of our time. I leave it to you to estimate the percentage of correct solutions in an ordinary scientist's work. Most of their lives are spent like Mr. Teeple's half-hour in the bathroom, thinking and thinking and getting nowhere.

But there's a more important reason why Archimedes' crying "Eureka!" isn't a good picture of a scientist. Today no scientist, dressed or undressed, would dream of telling people "I've found it!" as soon as he has hit upon a bright idea. Even less would he do the modern equivalent — announce his discovery immediately to the press. Just the contrary. He would take care not to breathe a word about it to anyone, but quietly go to his laboratory and run some tests — and more tests — and more tests.

A scientist today doesn't consider a bright idea as a revelation of the truth; he considers it as something to be disproved. Not just proved, mind you; it's his obligation as a scientist to think of every conceivable means and ways to *dis*prove it. This habit is so ingrained in him that he doesn't even realize it any more; he automatically thinks of a theory as something to find flaws in. So he does experiments and hunts for every error he can possibly think of; and when he is through with his own experiments, he publishes his findings not in a newspaper but in a scientific journal, inviting other scientists to do some other experiments and prove him wrong.

And when the hunt for errors has subsided and a theory gets established and accepted — do scientists think they've got hold of a new truth? No. To them, all scientific findings are only *tentative* truths, "good until further notice," to be immediately discarded when someone comes along with another theory that explains a few more facts. Absolute truth doesn't even interest them; they get along very happily, thank you, with a set of working hypotheses that are good only at certain times and for certain purposes. The most famous example of this today is the theory of light. There is a wave theory that fits certain investigations, and a particle theory that fits certain others. Years ago physicists stopped trying to find out which is true and which is false. The Danish Nobel prize winner, Niels Bohr, has called this the principle of complementarity, saying that after all "waves" and "particles" are only handy metaphors in dealing with certain facts; so why not use whichever is more practical at the moment? Never mind what light is "really"; let's get on with the job of finding out what it *does*. Or as one physicist said, "Let's use the particle theory on Mondays, Wednesdays, and Fridays, and the wave theory on Tuesdays, Thursdays, and Saturdays."

For the layman, the most important thing about science is this: that it isn't a search for truth but a search for error. The scientist lives in a world where truth is unattainable, but where it's always possible to find errors in the long-settled or the obvious. You want to know whether some theory is really scientific? Try this simple test: If the thing is shot through with *perhapses* and *maybes* and hemming and hawing, it's probably science; if it's supposed to be *the* final answer, it is not.

So-called "scientific" books that are supposed to contain final answers are never scientific. Science is forever self-correcting and changing; what is put forth as gospel truth cannot be science.

But what does *science* mean? If someone asked you for a definition, you'd probably be on the spot. If pressed, you might come up with something like the definition in Webster's: "A branch of study . . . concerned with the observation and classification of facts, esp. with the establishment . . . of verifiable general laws . . ."

That's a pretty good description of what the word means to the average person. Does it mean the same thing to scientists? It does not. Recently President Conant of Harvard, a chemist, published *his* definition of science: "An interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observation." As you see, the two definitions are almost exact opposites. *You* think science deals with facts; a scientist thinks it deals with concepts. *You* think science tries to establish laws; a scientist thinks it aims at more and more experiments.

And what is the scientific method? Your answer is apt to be: "The classification of facts." President Conant's answer is again different. Look up *Scientific method* in the index of his book, and you'll find this: "Scientific method. *See* Alleged scientific method." In other words, President Conant thinks there *isn't any* scientific method.

That surely is extreme. Even if there is no clearly definable scientific method, there's a way in which scientists work, and it's certainly worth knowing about. Let's look at a careful description by Dr. W. I. B. Beveridge, a British biologist:

> The following is a common sequence in an investigation of a medical or biological problem:
>
> (a) The relevant literature is critically reviewed.
>
> (b) A thorough collection of field data or equivalent observational enquiry is conducted, and is supplemented if necessary by laboratory examination of specimens.
>
> (c) The information obtained is marshalled and correlated and the problem is defined and broken down into specific questions.
>
> (d) Intelligent guesses are made to answer the questions, as many hypotheses as possible being considered.
>
> (e) Experiments are devised to test first the likeliest hypotheses bearing on the most crucial questions.

The key word here is *guesses* in (d). In the popular view the emphasis is on (b), the collection of data. But not among scientists. They like to distinguish between "accumulators" and "guessers," and they're pretty much agreed that it's the guessers that are important. In more fancy terms, you could say that the modern emphasis is on deduction rather than induction, or that the Aristotelian method is now more esteemed than the Baconian. What it comes down to is simply this: Our top scientists say we need more ideas rather than more facts; they want more Einsteins who just sit and think rather than Edisons who have a genius for tinkering in the laboratory. After all, Edison, as one of them has said, "was not a scientist and was not ever interested in science."

Meanwhile, our research relies far more on accumulating than on guessing. General Electric, with its training courses in "Creative Engineering," is the exception; the American Cancer Society, which is openly resigned to "whittling away at this mass of mystery," is typical of the general rule.

Which is why Dr. Sinnott, director of the Sheffield School of Science of Yale, said recently:

> It must be ruefully admitted that we have not produced our share of great new germinative ideas in recent years. In atomic research, for example, most of the fundamental theoretical progress was made either by European scientists or men who had received their training abroad. We are strong in application, in development and engineering, but much less so in the fundamental contributions of the theory on which all these are based. . . . We are in danger of being overwhelmed by a mass of undigested results.

And what is the method used by those hard-to-find "guessers"? If we try to analyze it, we come right back to Duncker's description of problem solving, to his "solutions from below" and "solutions from above." Scientific problems are solved either by finding a seemingly irrelevant key factor or by applying a seemingly unsuitable thought pattern. Which means that scientific discoveries are made in one of two ways: by accident or by hunch.

Take any history of science, and you'll find that it is a history of accidents and hunches. Both types of discoveries are equally fascinating.

If you're interested in accidents, for instance, scientific history looks like this:

In 1786, Luigi Galvani noticed the accidental twitching of a frog's leg and discovered the principle of the electric battery.

In 1822, the Danish physicist Oersted, at the end of a lecture, happened to put a wire conducting an electric current near a magnet, which led to Faraday's invention of the electric dynamo.

In 1858, a seventeen-year-old boy named William Henry Perkin, trying to make artificial quinine, cooked up a black-looking mass, which led to his discovery of aniline dye.

In 1889, Professors von Mering and Minkowski operated on a dog. A laboratory assistant noticed that the dog's urine attracted swarms of flies. He called this to the attention of Minkowski, who found that the urine contained sugar. This was the first step in the control of diabetes.

In 1895, Roentgen noticed that cathode rays penetrated black paper and discovered X-rays.

In 1929, Sir Alexander Fleming noticed that a culture of bacteria had been accidentally contaminated by a mold. He said to himself: "My, that's a funny thing." He had discovered penicillin.

Of course, all these accidents would have been meaningless if they hadn't happened to Galvani, Perkin, Roentgen, and so on. As Pasteur has said, "Chance favors the prepared mind." What is necessary is an accidental event plus an observer with *serendipity* — "the gift of finding valuable or agreeable things not sought for." (Horace Walpole coined that beautiful word.)

On the other hand, if you're interested in hunches, scientific history looks like this, for example:

Harvey describes his discovery of the circulation of the blood:

> I frequently and seriously bethought me, and long revolved in my mind, what might be the quantity of blood which was transmitted, in how short a time its passage might be effected and the like. . . . I began to think whether there might not be a motion, as it were, in a circle.

James Watt invents the steam engine:

> On a fine Sabbath afternoon I took a walk. . . . I had entered the green and had passed the old washing house. I was thinking of the engine at the time. I had gone as far as the herd's house when the idea came into my mind that as steam was an elastic body it would rush into a vacuum, and if a connection were made between the cylinder and an exhausting vessel it would rush into it and might then be condensed without cooling the cylinder. I had not walked further than the golf house when the whole thing was arranged in my mind.

Darwin writes about his theory of evolution:

> I can remember the very spot in the road, whilst in my carriage, when to my joy the solution occurred to me.

Kekule tells how he discovered the benzene ring on top of a London bus:

> I sank into a reverie. The atoms flitted about before my eyes. . . . I saw how two small ones often joined into a little pair; how a larger took hold of two smaller, and a still larger clasped three or even four of the small ones, and how all spun around in a whirling round-dance. The cry of the conductor, "Clapham Road," woke me up.

Walter B. Cannon discovers the significance of bodily changes in fear and rage:

> These changes — the more rapid pulse, the deeper breathing, the increase of sugar in the blood, the secretion from the adrenal glands — were very diverse and seemed unrelated. Then, one wakeful night, after a considerable collection of these changes had been disclosed, the idea flashed through my mind that they could be nicely integrated if conceived as bodily preparations for supreme effort in flight or in fighting.

Does all this mean that some scientists are good at hunches and some others blessed with serendipity? Not at all. The accidental clue needs a receptive mind; the hunch has to grow from a study of facts. The good guesser works both ways, depending on what he has to go on. Here's one more example that shows a combination of both methods. It is typical of modern scientific research in many ways.

During World War II, a team of psychologists studied the propaganda effect of orientation films. Among other things, they tried to find out whether films changed the opinions and attitudes of soldiers who saw them, and whether and how these changes lasted. They had a hunch that the effect of the films would gradually wear off and that after some time, soldiers would forget the factual details and revert to their original opinion.

This idea may seem rather obvious to you. It seemed obvious to the psychologists too — but, being scientists, they decided to test it anyway. So they gave the soldiers a test after one week and another test after nine weeks.

As expected, the soldiers had forgotten most of the facts in the film during those eight weeks. But, "clearly contrary to the initial expectation," the general propaganda effect of the film — the opinion change — had considerably *increased* between the first and second test. There was not the slightest doubt about it: the soldiers had forgotten the details of the film, but its message had sunk in deeper.

The research team cheerfully accepted this unexpected fact and immediately proceeded to account for it by a hypothesis. They found that it could be explained through a theory by the British psychologist, Bartlett, published in 1932. Bartlett had written that "after learning, that which is recalled tends to be modified with lapse of time in the direction of omission of all but general content and introduction of new material in line with the individual's attitudes." In other words, as time passes, we're apt to forget details but reinforce what we remember of the general idea.

Well, what have we here? Doubtless the research team made a valuable discovery. Yet the whole story is as unlike that of Archimedes in his bath as can be. For one thing, there is no single scientist, but a team of thirteen men and two women. Second, the discovery is exactly the opposite from what the scientists expected to find. Third, it is immediately connected up with an idea thought up by another scientist in another country, twenty years before.

And finally, there is no "Eureka!" no shouting from the housetops, no happy announcement to the world. Instead, after reporting their discovery and stating their hypothesis, the researchers add casually: "These highly speculative suggestions indicate some very interesting areas for future research."

❦

SUGGESTIONS FOR FURTHER READING

Conant, James B. *Science and Common Sense.* New Haven: Yale University Press, 1951. An unusually successful attempt to make science clear to those with no scientific preparation.

Cantril, Hadley. Psychology. *Scientific American,* September, 1950, pp. 79–84. A brief and interesting history of psychology.

Dennis, Wayne. Animistic thinking among college students. *Scientific Monthly,* 1953, 76, 247–249. An investigation of the unscientific beliefs of college students.

Michael, D. N. Scientists through adolescent eyes: what we need to know, why we need to know it. *Scientific Monthly,* 1957, 84, 135–140. Concerning the problem of the image of scientists in high school students and how we might attack the problem of interesting them in science.

ART II

Psychology Is the Science of the Behavior of Organisms

THE INTEREST PEOPLE HAVE IN THEMSELVES AND IN OTHERS IS BASIC, UNIVERSAL, AND enduring. Psychologists, being human, share this interest and express it by embracing psychology as a profession, working toward the solution of theoretical and practical problems which are concerned with human activity. As psychology pursues the theoretical goals, it is known as the science of the behavior of organisms, and in this role it seeks to establish a systematic, universal, and verifiable body of knowledge concerning the behavior of organisms. As psychology pursues the practical goals, it is known as one of the practicing arts and as such it is a vital part of our modern culture. This distinction between the basic aspects and the applied aspects of the science was discussed in earlier selections. It should be noted that the applications which contribute to human betterment depend upon the establishment of theoretical principles. On the other hand, practical problems often give rise to theoretical issues not yet solved. So the two kinds of activities are dependent upon each other.

Psychologists sometimes despair of getting across to the public an uncluttered picture of their science. The term psychology frequently is used loosely, is distorted, and is even adopted for questionable purposes. Articles in Part II have been chosen to indicate as clearly as possible just what psychology is. First we shall see how psychology is presented to the public through the writing of a successful journalist and then we shall turn to an article which might have been titled "Inside Psychology," since it depicts psychology as seen by one of its members. Emphasis in the remaining articles of the section is on the scientific aspects of psychology, its starting assumptions, its goals, its methods of investigation, and the direction it has taken to find its most significant explanations.

7

The Age of Psychology in the U.S.

ERNEST HAVEMANN

The series of five articles about psychology and psychiatry which Mr. Havemann prepared for *Life* magazine received a great deal of attention from both laymen and professional psychologists. It was probably more widely read than any other series on the subject. The American Psychological Foundation recognized its importance by giving Mr. Havemann its first distinguished writing award in 1957. In the article which follows, the author describes the impact of psychology on American life and some of the problems created by that influence. He distinguishes clearly each of the three specializations so often confused — psychology, psychiatry, and psychoanalysis.

Mr. Havemann is a professional journalist who also holds the MA degree in psychology. His articles have been printed in a book entitled *The Age of Psychology*, © 1957, by Ernest Havemann. The selection which follows is from *Life's* first installment (January 7, 1957). It is reprinted by permission of Simon and Schuster. Another selection from the series appears in the last part of this volume.

After getting up the other day, John Jones, American, shaved with a razor he had bought on the strength of a magazine ad approved by the head psychologist of an advertising agency. At his breakfast table, in his morning newspaper, he read two columns of psychological fact and advice. One told him that women were absolutely not more intuitive than men, all popular opinion to the contrary notwithstanding. The other invited him to find his "happiness quotient" by answering a series of 10 questions. He then drove to work, guided by road signs painted yellow and black because a psychologist once discovered that these colors make for easier reading. At the plant he walked past the office of the company psychiatrist, where he would have been free to go in and seek counsel had he felt especially disturbed about anything that morning, and got right to work at his job, to which he had been promoted after taking a series of psychological tests.

Among his other duties this particular morning was a conference with an industrial psychologist who had been retained to advise on the company's pending contract negotiations with the union. At noon, over his lunch, he read two more psychological columns in his afternoon paper, one telling him how to improve his relations with his mother-in-law, the other advising a letter writer that her errant husband probably had a mother fixation. He also read in his favorite gossip column that one of his pet movie actresses, about to go on location in Africa, was taking along her personal psychoanalyst lest she lapse into another of her spells of melancholy. In the afternoon he faced an office crisis because a psychological research firm, hired to poll the public's opinion of his company, had found a marked loss of goodwill in the preceding six months. When he went home at night he found his family in something of a dither because his youngest son had been called in for a conference with the school psychologist; subject matter, repeated impudence to the second-grade teacher. To relax he took his wife to a movie, where the first half of the double feature took place in a mental institution and the second half contained a sort of farcical psychoanalyst strictly for the laughs. They arrived home just in time for the late TV newscast, which informed them that government officials were in a hassle over how much money to spend on psychological warfare.

All these things might have happened to any American last week. They could not have happened in any previous generation and they could not have happened even last week in any other country, for widespread use of psychology as an applied science of everyday living is brand-new and strictly American. The birth of modern psychology took place less than 100 years ago, of psychoanalysis scarcely more than 50. In many parts of the world all knowledge of them is still restricted to the college classroom or the doctor's office. But in the U.S., for better or worse, this is the age of psychology and psychoanalysis as much as it is the age of chemistry or the atom bomb.

In many ways the practitioners of psychology are too intriguing for their own good. Every scrap of information about them is eagerly gobbled up, whether authentic or not, so that a good deal of what the public has come to believe is utterly wrong. Psychiatrists often find that new patients have misconceptions which hamper their treatment for months. Psychology professors starting a freshman class usually find that they must sweep their students' minds free of a great deal of misinformation before they can begin any constructive teaching.

Psychology is probably misunderstood for the same reason it is so popular: it deals with a subject on which people have always considered themselves to be authorities. The layman has never boggled at expressing and swallowing the most sweeping judgments on human nature and its aberrations. One indication is the widespread popularity of such age-old saws as "Early to bed," "All work and no play," "Still water runs deep" and the like, many of which, by the way, are mutually contradictory. The psychologist, the psychiatrist and the psychoanalyst all operate within the general area delineated by the old saws about the nature of man, with these differences:

The *psychologist* searches for a scientific understanding of how people see and hear, his interests thereby overlapping those of the physiologist. He also tries to find out how they learn, how they feel and express their emotions and how they get along (or do not) with their fellow men, at which point he and the sociologist are on somewhat similar ground. The psychologist once was chiefly a research specialist and teacher; he began by applying scientific methods of observation and measurement to human behavior, and instructing others in what he found. Many psychologists are still interested only in "pure science" — that is, in fact and theory. A majority of them, however, have branched out into applied psychology, attempting to use their knowledge to help people live happier and more efficient lives. Some of them, for example, counsel young people on what vocations to choose or advise businessmen on how to provide better working conditions for their employes. Quite a number of them work at what is called clinical psychology, which is an attempt to help individuals who have emotional problems and personality maladjustments.

The *psychiatrist* is also interested in human psychology, but as a physician attempting to understand and treat the people in whom something has gone wrong. He specializes in the care of what used to be called insanity (but what he now calls psychosis, the victims being known as psychotics) and less severe mental disorders (which he calls neuroses, the victims being called neurotics). Most psychiatrists work in public and private hospitals. About two thirds of them also have private practices, in which they treat patients whose difficulties are not severe enough to require hospitalization.

The *psychoanalyst* is a special kind of psychiatrist. He too is a physician (except for a few "lay analysts" admitted to practice in the earlier days of analysis) who treats the mentally ill. But he uses a special type of treatment originally developed by Dr. Sigmund Freud. Under this method the analyst spends hundreds of hours listening to the patient discussing his past and present life, his dreams and his daydreams. Finally the patient's pattern of so-called "unconscious" or hidden problems emerges to the point where it can be straightened out.

We all have friends nowadays who can tell us, using such psychological or psychiatric terms as extrovert, introvert, frustration, tension, sublimation and psychosomatic, exactly what is wrong with the way we get along with our wives, rear our children, deal with our bosses and approach our hobbies. A great many people embrace and spout this kind of psychological lingo without really knowing the first thing about it. And for this reason a lot of other people have come to hate the very mention of psychology without understanding it either.

Another cause of confusion is the fact that a lot of people have jumped on the psychology bandwagon without the proper qualifications or caution. Most of the popular books, magazine articles and newspaper columns containing psychological "fact" and advice absolutely appall most professional psychologists and psychiatrists. A good case in point is the column called "Know Thyself," which appears in the New York *Post* and the Philadelphia *Daily News*. Readers of "Know Thyself" are invited to score themselves every day on questionnaires purporting to determine such questions as these: "Do you have social poise?"

"Are your emotions under control?" and "How happy are you?" It would be perfectly possible, in the opinion of most psychologists, to score 100% on such a test on Monday — and on Tuesday have a complete nervous collapse. As for the numerous columns which supposedly clear up any human problem in a hundred well-chosen words, one psychoanalyst has said: "This is the most amazing thing in the world. The columnist reads a letter from a perfect stranger and that very day states the exact nature of his problem and recommends a cure. Most of us would be happy if we could analyze the problem in years of intensive work — and we'd have to leave any 'cure' up to the patient himself."

Yet, right or wrong, serious or frivolous, practically anything relating to psychology and psychiatry finds a big audience. Nine out of 10 of the major U.S. daily newspapers carry at least one column of psychological lore. If the syndicate figures are to be believed, a column called "Child Behavior" has a circulation of 9.5 million; "The Worry Clinic," 19 million; "Mirror of Your Mind," 20 million; "Let's Explore Your Mind," a question and answer column illustrated with cartoons, is said to have a circulation of 21 million and to draw nearly a million requests a year for the 10¢ and 15¢ pamphlets offered by the column under such titles as *How to Find Your Happiness Cycle, Facing the Facts of Married Life* and *How to Manage Your Feelings and Emotions.* Psychiatry has even invaded the newspaper comic strips. In *Rex Morgan, M.D.*, the current episode concerns an old man with senile dementia. This strip, it so happens, is written for his own amusement and profit by a practicing psychiatrist of Toledo, Ohio.

Books of psychology or psychiatry for the layman often become best-sellers. A writer named Lucy Freeman told the story of her own psychoanalysis in *Fight Against Fears*, which sold 35,000 hard-cover copies, and 330,000 in a paperback edition. She followed this with *Hope for the Troubled*, a discussion of the various types of psychological assistance, which has sold 140,000 copies. (There is an even greater sale of those perennial best-sellers, the self-help books — like Dr. Norman Vincent Peale's *The Power of Positive Thinking* or Harry Overstreet's *The Mature Mind* — but strictly speaking these books have to be classed as inspirational rather than psychological, though many of them also expound psychology in keeping with the trend of the times.) Even books designed for professional psychologists and psychiatrists — and consequently full of the most complex and esoteric kind of language — are having a big sale among laymen. *The Basic Writings of Sigmund Freud*, published as a 1,000-page Modern Library Giant at $2.45, has sold over a quarter of a million copies.

. . . .

All in all the number of those trained and working in the field of psychology and psychiatry is leaping ahead almost by geometrical progression. Many experts think that our present 16,000 psychologists will grow to more than 30,000 in the next 15 years, our present 10,000 psychiatrists (including psychoanalysts) to perhaps 17,000 or even more. All indications are that the expansion of psychology and psychiatry up to now — as spectacular as it has been — is only the beginning.

8

Psychology in Mid-Twentieth Century

JOSEPH R. ROYCE

Having read Mr. Havemann's account of the influence of psychology on modern American civilization, we turn now to Dr. Royce's more intensive look at the internal organization of psychology and some of its more important specializations. He mentions a number of laboratories and psychologists identified with significant contributions to behavior science, and he shows how psychology is related to both the biological and the social sciences. This article also provides the reader with some notion of how extensively psychology, like other sciences, has branched out.

Dr. Royce is associate professor of psychology at the University of Redlands. He formerly held several research posts and taught at Drake University. The following article appeared in the *American Scientist* for January, 1957 (pp. 57–73), and is reprinted by permission of the publisher and the author.

In the fiscal year 1953–1954 over ten million dollars were spent for research in the field of psychology. While this is a small amount when compared with research expenditures in the physical sciences, it suggests that large numbers of psychologists are busily engaged in the business of finding out new things about the nature of human behavior. It is doubtful if any other science in history has had so much research money available to it at such a youthful age.

In 1945 the American Psychological Association had around 3000 members; in 1955 the membership of the APA was 13,475. The structure of the APA has changed from a single society to an assemblage of societies which takes the form of seventeen divisions reflecting the specialized interests of different groups of psychologists. The national meetings of our society used to be held annually at various universities throughout the United States. The attendance at these meetings is now so large that very few universities can adequately house the delegates; the APA convention is being held more and more often in large hotels in big cities. The digest of the psychological literature of the world, Psychological Abstracts, searches through close to 500 journals which contain contributions relevant to the advancement of psychological knowledge. The breadth of coverage which these journals provide is staggering. Psychologists have stepped outside their ivory towers into the market place, the hospital, the government offices, and the military base. There are now more psychologists employed in nonacademic positions than in all academic posts combined. There is hardly a nook or cranny of life where their behavioral investigations have not been conducted. Exactly what kinds of things are these psychologists doing? What kinds of questions are behavior scientists and practitioners trying to answer? To what extent is psychology a science? Our purpose is to shed some light on these and other questions concerning contemporary psychology.

MAJOR FIELDS AND APPLICATIONS OF CONTEMPORARY PSYCHOLOGY

If we think of philosophy as the major tributary in the historical stream of knowledge, with modern specialization branching off from this central source, we find that psychology is the most recent scientific offshoot. From its simple beginnings in sensory psychophysiology in the 19th century to the present day, the field of psychology has proliferated and expanded in a manner typical of the older, more mature sciences. In addition to expanding the fundamental approaches (i.e., "pure" science) to scientific knowledge, psychology has also moved into many applied areas. This growth has been so extensive that it is difficult to encompass it. At least part of the reason for the diversity of modern psychology is due to the multiplicity of its origins. Medical men, biologists, neurologists, and physiologists, for example, have all had a hand in the early history of psychology. Psychiatry, a medical specialty, stressed the importance of studying the abnormal. And students of the brain could not help but wonder if their observations of what went on inside the skull had anything to do with their own behavior. Anthropologists stressed culture as the determining social matrix which shapes the personalities of men. And certain thinkers with a mathematical orientation stressed the importance of measurement and of quantitative approaches in the study of behavior. Each of these points of view has found a fruitful outlet in psychology.

Another reason for the diversity of contemporary psychology is the demand which society has placed on the field for useful knowledge. The state mental institutions cry out for more fundamental knowledge concerning how their patients got that way. The psychobiology of feeble-mindedness remains a big unknown so that the state, again, must bear the burden of housing and caring for large numbers of incompetents. Industry is becoming increasingly concerned with how to select and assign the best man for the right job, and of course, all businessmen are concerned with psychological techniques which might tell them more about what people will buy. The military and government agencies are very much concerned with problems of morale, efficiency, leadership, psychological warfare, and maximum productivity. These various and sundry intellectual and practical forces have pushed and pulled psychology in a truly fantastic variety of directions. It leads one to the conclusion that wherever there are people, whatever they are doing, or feeling, or thinking, there is at least one psychologist lurking around making a study of these doings, feelings, or thoughts. How can we view this many-headed monster we call psychology? I propose that we view it piecemeal at first, and reserve our over-all view for later. We can facilitate this approach by referring to Chart 1 [see p. 33].

The upper section of this chart shows the relationships between modern psychology and its most closely related fields. Thus, along an imaginary horizontal axis we note that the most closely related natural science is biology, anatomy and physiology in particular. Less closely related are the fields of physics and chemistry. Similarly, we note the importance of the fields of anthropology, sociology, and education. Along an imaginary vertical axis we note that psychology, like all other scientific fields, is continuously striving for greater and greater quantification. Thus, we have inserted a wide band denoting mathematics, indicating that mathematics underlies all fields of knowledge which strive to be scientific, whether pure or applied.

The major "pure" fields of psychology have been indicated in small, solid line rectangles. Most of these fields grew out of alliances with the natural and social sciences. The broken line rectangles represent the major fields of application which grew out of the subdivisions of psychology. The connecting solid lines show the major influences which were important in the development of a given field. The connecting broken lines denote secondary influences. The text which follows will be organized in terms of this chart. The applications which are primarily associated with a particular basic field will be discussed in the second portion of each section. The reader should coordinate the reading of the following sections with frequent glances at the relevant portion of Chart 1.

EXPERIMENTAL PSYCHOLOGY

The contemporary field of psychology known as "experimental" is a misnomer. When the grandparents of this field started it somewhere around 1840–1870 it was known as psychophysics; they were concerned with relating psychological or subjective experiences to physical stimuli. The major goal in these early years of Weber, Fechner, and Wundt was to show that psychological problems could be attacked scientifically. After all, this had not been demonstrated before, and since the last word in being scientific was to be able to set up an experiment, it was important to these early men that they make their point, and make it repeatedly. Over the years, psychologists who identified themselves with this aspect of psychology literally became missionaries of science in spreading the gospel of experiment to a wide variety of behavioral phenomena. At first psychological experiments were conducted on the relatively simple phenomena of sensations and reaction time. Later Pavlov, Watson, and Ebbinghaus carried the banner to conditioning and learning. The Gestalt psychologists conducted brilliant qualitative experiments on perceptual phenomena in the 2nd and 3rd decades of the twentieth century, and today we find very few areas of psychology in which true experiments have not been carried out. Organisms have been rendered experimentally neurotic, hallucinations have been experimentally induced in monkeys and men, the effect of various group pressures on individual opinions and attitudes has been subjected to ingenious experimentation, and inroads have been made in setting up experiments on the processes of concept formation and thinking. In other words, all of psychology is experimental. There are, of course, many specific problems which are still refractory to experimentation. For example, although unconscious conditioning has been repeatedly demonstrated in the laboratory, nobody has devised an experimental approach to the study of dreams. And most of what Freud, Adler, Jung, and the other psychoanalysts write about is not based on experimental findings. Despite the misnomer, however, the field of experimental psychology is shedding its methodological connotations and has come to mean the psychology of conditioning and learning, the psychology of sensation and perception, and the psychology of motor phenomena. The experimental literature in each of these areas is vast. It represents little risk to prophesy that the term experimental psychology as a description of a basic field will be dropped from common usage

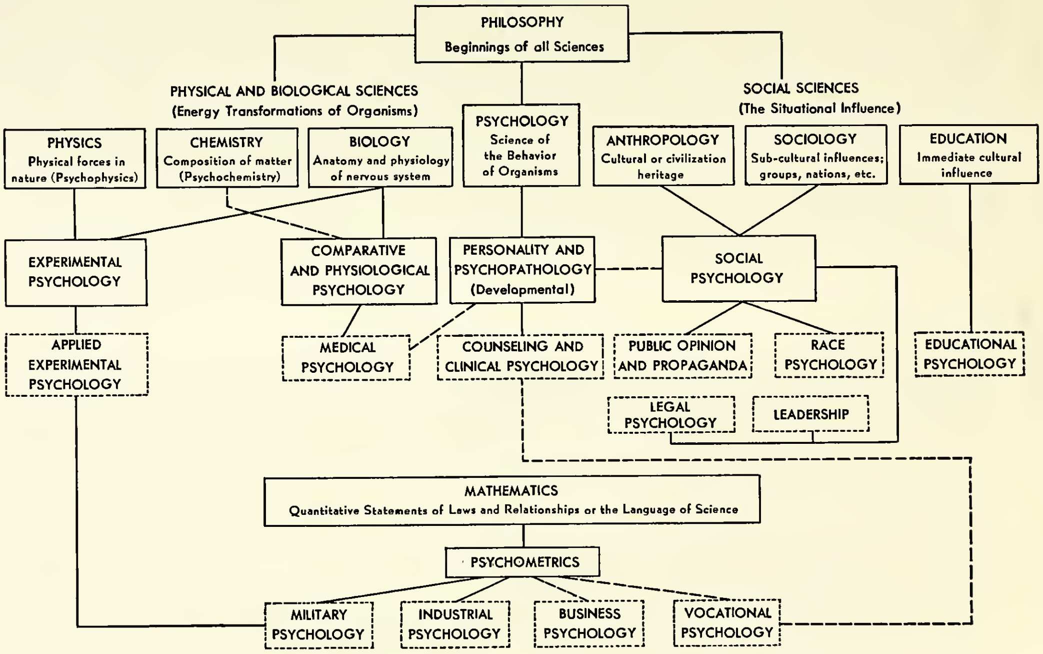
PHILOSOPHY
Beginnings of all Sciences
PHYSICAL AND BIOLOGICAL SCIENCES
(Energy Transformations of Organisms)
SOCIAL SCIENCES
(The Situational Influence)
PHYSICS
Physical forces in nature (Psychophysics)
CHEMISTRY
Composition of matter (Psychochemistry)
BIOLOGY
Anatomy and physiology of nervous system
PSYCHOLOGY
Science of the Behavior of Organisms
ANTHROPOLOGY
Cultural or civilization heritage
SOCIOLOGY
Sub-cultural influences; groups, nations, etc.
EDUCATION
Immediate cultural influence
EXPERIMENTAL PSYCHOLOGY
COMPARATIVE AND PHYSIOLOGICAL PSYCHOLOGY
PERSONALITY AND PSYCHOPATHOLOGY (Developmental)
SOCIAL PSYCHOLOGY
APPLIED EXPERIMENTAL PSYCHOLOGY
MEDICAL PSYCHOLOGY
COUNSELING AND CLINICAL PSYCHOLOGY
PUBLIC OPINION AND PROPAGANDA
RACE PSYCHOLOGY
EDUCATIONAL PSYCHOLOGY
LEGAL PSYCHOLOGY
LEADERSHIP
MATHEMATICS
Quantitative Statements of Laws and Relationships or the Language of Science
PSYCHOMETRICS
MILITARY PSYCHOLOGY
INDUSTRIAL PSYCHOLOGY
BUSINESS PSYCHOLOGY
VOCATIONAL PSYCHOLOGY

Chart 1. Major fields and applications of contemporary psychology.

by the end of the 20th century, and that each of the major segments of this broad area will become a specific area in its own right.

The field of applied experimental psychology is a post-World War II phenomenon. The need for applying what was known about a person's senses and perceptual-motor capacities grew primarily out of the highly technical demands of fighting a modern war. Much of what man does in carrying out an Atomic Age war is to manipulate mechanical and electronic gadgets of various kinds. This puts a very high premium on how well man's receptors and effectors can perform. It was found repeatedly that man could not keep up with the complexity of most of the World War II machines. Human factors all too frequently were found to be the weak link in the military chain of events. The cockpit of a modern bomber, for example, was constructed without regard to the limitations of the human operator. Panels of dials were set up with the zero points at different positions on the dial face. Important levers were pushed or pulled in various directions; sometimes they had to be manipulated without the pilot being able actually to see the lever before moving it. The military has come to realize the tremendous importance of understanding the operation of the man as well as the machine. And so the field of engineering psychology or applied experimental psychology has been created primarily out of the "pure" psychology of sensation and the "pure" psychology of perceptual-motor phenomena. Thus, the aviation psychologists at the Aero-Medical Laboratories in Dayton, Ohio, have been concerned about the various shapes and sizes of levers to be identified by touch sensitivity in the redesigning of the lever system of the modern bomber. The psychophysicists of the Navy, working with the engineers at the Navy Electronics Laboratory in San Diego, have worked on various visual problems which are involved in rapidly scanning a radarscope. And RAND Corporation, the private research and development arm of the Air Force, finds itself working on mammoth projects involving complicated "systems" of men, communications, and machines. As with psychological testing during and after World War I, the military again seems to be pointing the way for industry and government. With automatic factories and offices (i.e., automation) practically around the corner, the time is now for private enterprise to begin getting its feet wet in the business of coupling man's receptor and motor equipment to the already well advanced electronic equipment.

COMPARATIVE AND PHYSIOLOGICAL PSYCHOLOGY

The field of comparative and physiological psychology has two major streams feeding into it. The comparative or animal psychology stream was started by the evolutionary theory of Darwin. It is similar to its sister areas, comparative anatomy and comparative physiology. A true comparative psychology is concerned with descriptions of the psychological processes of all animal forms from amoeba to man. Although a tremendous mass of factual data has been gathered and summarized by phyla (*1*), it is unfortunately true that recent developments in this area suggest that it would be more accurate to describe comparative psychology as rodent psychology. This trend is primarily due to the effects of neo-behaviorists to establish elementary laws of conditioning and learning in a relatively simple animal under relatively simple experimental conditions. The thinking is that the rat is a handy and relevant animal to use in carrying out such a program; that a behavior system which will predict rat behavior will eventually also help us understand human behavior. If we add the college sophomore as another favorite subject, we see what is behind the often heard statement that psychology is the science of the behavior of the rat and the college student.

Physiological psychology grew out of the early concern for the nervous system. The physiologically oriented psychologist is concerned with correlating what goes on under the skin with what goes on outside the skin. He believes there are internal mechanisms which are the major determinants of responses. In such a view the stimulus simply triggers a series of events which eventuate in a given, specifiable response. The physiological psychologist is still very much concerned with stimuli and responses, but he believes the physiological linkage between the two is the key to real understanding. And so he conducts brain damage studies in an attempt to localize intelligent behavior, administers vitamins and drugs in an attempt to make learning more efficient, or introduces electroshock in order to determine its effect on memory.

It becomes immediately apparent that while the physiological psychologist may use human subjects, most of his problems can be more adequately handled with animals. This is one of the major reasons that comparative and physiological psychologists fall rather naturally into a joint area of knowledge. It is important to note that the comparative-physiological psychologist does not pick his subjects at random or simply for the sake of convenience. A good knowledge of the special anatomical and physiological characteristics of a wide variety of animal species is extremely important in this area. Only this kind of information will lead the investigator to the most appropriate animal form for a given problem. For example, suppose we are interested in trying to determine the extent to which either a brain or a nervous system is required in order to elicit a conditioned response. Since it has only a very primitive brain, the earthworm would be an appropriate animal to include in testing for the first part of the question. And since the amoeba is essentially a glob of protoplasm, it would be relevant to the second part of the question. An answer to this question has, in fact, been put to the test on many animal forms. The answer seems to be that neither a brain nor a nervous system is necessary for conditioning. All that is necessary is some medium of conductivity. Single-celled animals have been conditioned after hundreds of training trials, and worms have been trained to make the proper choice in a simple T maze after 150 trials or even less. Since few psychologists or zoologists will be able to learn enough about the one million or so animal species, a certain degree of specialization is inevitable. Because of their obviously closer relevance to man, psychologists have stressed the importance of vertebrates, mammals in particular. When he was a young man Robert M. Yerkes had a dream about a laboratory devoted to the psychobiological study of subhuman primates. After a World War (1918), a decade or two of struggle, some luck, but mostly determination, he was able to establish the now famous Yerkes Laboratories of Primate Psychobiology at Orange Park, Florida. This laboratory, cooperatively administered by Harvard and Yale Universities, has been under the directorship of the great neuropsychologist Karl S. Lashley. The researches on monkeys, chimpanzees, gorillas, and other primates, which emerged from this laboratory are the most authoritative sources of information we have on the behavior of man's closest animal relative. Yerkes' early volumes on this subject are still regarded as the most comprehensive coverage of their social, mental, and emotional behavior.

A similar laboratory, devoted primarily to the study of conditioning and experimental neurosis, has been in existence for several decades at Ithaca, New York. It is called the Cornell Behavior Farm. It is administered by Cornell University and has been under the guidance of H. S. Liddell from the time of its founding. Scientific work of great importance to psychosomatic medicine and experimental psychopathology has been conducted at this laboratory.

The only experimental animal psychology laboratory in the world which exists independently of a university, hospital, or other type of "administrative" institution, is the recently established Hamilton Station, 8 miles outside of Bar Harbor, Maine. This converted farm, established as part of the Roscoe B. Jackson Memorial Laboratory (genetics and cancer) in 1945, was financed by the Rockefeller Foundation for the purpose of conducting long range research on the relationship between genetics and behavior. The major portion of the research program involves the use of various breeds of dogs. Since there are over one hundred different breeds, and since the dog is a complex enough animal to exhibit social, emotional, and intelligent behavior, the dog is a perfect animal form to use in studying the relationship between heredity and behavior. Most other comparative physiological laboratories exist as a relatively small part of the larger American universities. There are very few animal psychology laboratories in other countries. In continental Europe most of the animal research is conducted by zoologists. In England, despite the influence of Darwin and other early British biologists, there has been surprisingly little interest in this area. While some interest in physiological psychology is world wide, the animal approach to physiological and other behavioral problems seems to be a typically American enterprise.

The applications of comparative and physiological psychology are difficult to place under a single heading. For example, the animal research on experimental neurosis is relevant to the field of clinical psychology and the research on heredity and behavior is of importance to the field of education. However, many of the research findings in this area are not immediately of practical value. Of the various basic fields of psychology, this one is about as "pure" as they come. The findings which do have "immediate" practical implications are primarily in the area of medical psychology. The first experimental pre-frontal lobotomies, for example, were conducted on monkeys by the psychologist Carlyle Jacobsen at the State University of Iowa in the nineteen-thirties. Psychosomatic medicine will look increasingly to comparative-physiological psychology, as well as to students of personality and social psychology, for greater understanding of psychogenic illnesses.

The various physiological approaches to problems of mental deficiency and mental illness show promising signs for the future. For example, there is some evidence that both carbon dioxide therapy and electroshock treatment improve certain types of mental disease. Perhaps the most dramatic psychiatric improvements, however, have been due to the effects of two drugs, chlorpromazine and reserpine. Their calming effect seems to be particularly effective in counteracting various manic psychotic states. There is also conflicting evidence concerning the ameliorative value of vitamins and glutamic acid when given to feeble-minded children. At mid-twentieth century the promising correlation between the biological and the psychological has just begun.

PSYCHOMETRICS

The field of psychometrics grew directly out of practical demands placed on the authorities of the French school system. These educators were concerned with the problem of teaching very bright, average, and very dull children in the same classroom. They approached the famous psychologist Alfred Binet with this problem in 1900. This started a series of events which resulted in the development of one of the most widely used testing instruments in the history of psychology. Terman's 1937 revision of the Stanford-Binet test grew directly out of the many earlier revisions of Binet's test of 1905. The inadequacies of testing for adult intelligence with the school-child oriented Binet test were soon felt by psychologists working in clinics and hospitals. And so the Wechsler Adult Intelligence Scale was developed and found to be much more suitable. It is interesting to note that Wechsler's Child Scale has been making strong inroads in replacing the Binet test in many school systems and child guidance clinics. This development is at least partially due to the relative ease of administering the Wechsler test in contrast to the cumbersome age-scale Binet test.

Following the tune of practicality, the test makers of World War I, faced with the problem of having to test thousands of recruits in one day, came up with the simple idea of developing standardized tests which could be administered in large groups. This simple maneuver freed the test makers from the limitations of time and expense which is so typical of individually administered tests. It also allowed them to take off in many directions, so that today we have hundreds of tests of intelligence, aptitudes, achievement, interest, and personality. With the duplication of group tests of intelligence, and every psychologist yelling "eureka!" every other year and proclaiming that he had developed the intelligence test to end all tests, the general public and fellow psychologists began to look with suspicion and with interest at what was going on. The suspicion expressed itself in the form of selecting and developing tests a little more carefully, especially with regard to such matters as reliability and validity. The interest expressed itself in the form of intercorrelating various combinations and batteries of tests.

After several decades of being led by the nose by practicality the test experts finally settled down to the more important and fundamental problems of measurement. If we look more carefully at the term psychometrics — almost literally psycho measurement — we cannot help but realize that the problems connected with measuring must be solved first before a full grown technology can be developed. For years Guilford's book, *Psychometric Methods*, was the only reference work which contained a compilation of guiding principles for the psychometrician. Gradually a more mature mental test theory has begun to come on the scene *(2)*. Psychologists are analytically describing several different types of test reliability and validity, they are minutely examining each item of a test and revising the item composition in terms of objective criteria, and they are asking searching questions about what it means to measure. Perhaps the most important of these recent theoretical developments has been the development of factor analysis.

The factorial approach can best be explained by an analogy. Many centuries ago early scientists described physical phenomena in terms of relatively gross units such as water and fire. Today the chemist does not speak of water, but rather of so much hydrogen and so much oxygen. In other words he has broken down a relatively complex phenomenon, water, into its component parts. Exactly the same step is taken in the factorial study of behavior. Let us take intelligence as an example. For the first few decades of modern psychology's existence the professional psychologist went along with the thinking of the man on the street concerning the nature of intelligence — namely, that if a person is smart, he is smart at everything. If he is stupid, he is stupid at everything. This general intelligence concept is essentially what is behind the Binet, the Wechsler, and most of the early group varieties of intelligence test. We come out with a single index of intelligence, the I.Q., which is supposed to tell

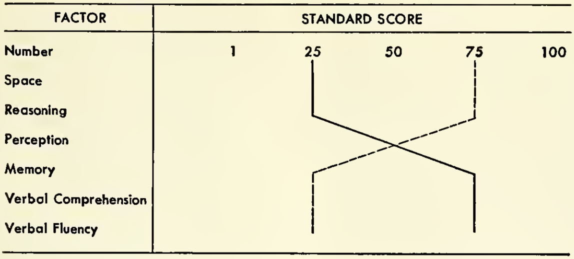

Chart 2. Showing two persons, *A* (solid line) and *B* (dotted line) with the same I.Q. but with opposite mental ability profiles.

us everything about a man's intelligence. Factor analysis has shown us that intelligence is not the unitary phenomenon most of us believed it to be, but rather, it is a complex, like water, which can be broken down into component parts. Some of the component parts of intelligence are Memory, Space, Reasoning, Perception, Number, Verbal Comprehension, and Verbal Fluency. Individuals differ in their particular profiles. Person A may be high in the Number, Space, and Reasoning components and relatively low in all the others, whereas person B may be just the reverse. In this connection it should be noted that these two individuals could even have exactly the same I.Q., but the distribution of their high and low points would differ. This point is brought out graphically by the two profiles depicted in Chart 2. If we average each of these two profiles, we get exactly the same value, namely, 50. This would be equivalent to an I.Q. of 100. If the I.Q. was the only information available we would conclude that these two individuals are intellectually identical. It is obvious, however, that they are identical only in their performance on the perception factor. Otherwise, person A is essentially quantitative in his intellectual strength whereas person B is essentially verbal. The theoretical and practical implications of this relatively new analytical approach are truly revolutionary. Factor analysis provides the psychometrician with an analytical model which goes beyond intelligence to include the entire gamut of testing (and perhaps of behavior). In addition it provides a mathematical method, based on matrix algebra, which is elegantly precise and beautifully appropriate to the multiple variable field of psychology (3). And finally, it provides the educational and vocational guidance expert with the kind of useful information he would not want to do without. A vocational counselor can certainly offer more assistance to a counselee with the profile kind of information available in Chart 2 than he can with the information that the counselee has an I.Q. of 100.

The implications of psychological testing have not escaped the eyes of business and industry. Many of the larger companies of the United States use tests in one way or another. The impetus to testing from World War II has been so great that a rash of industrial consulting firms broke out in New York, Chicago, and Los Angeles during the post-war years. While these industrial psychologists also consult on matters other than testing, the original stimulus for consulting work came from the demand for tests. The applications of personnel psychology have been considerable in schools and government, in addition to industry and the military. The federal and local civil service organizations frequently use commercially available tests in addition to their own home grown variety. The U.S. Civil Service Commission has a large staff of trained personnel psychologists in the various headquarters centers in Washington. Most universities make use of admission tests, diagnostic placement tests, and standardized achievement batteries in addition to the testing which goes on at a centralized examining board or a college counseling service. And many high school and elementary school systems are availing themselves of school psychometrists and school psychologists to integrate and administer their testing and vocational guidance programs. There can be little doubt of the tremendous need for and use of psychological tests.

PERSONALITY AND PSYCHOPATHOLOGY

Our view of the area of personality-psychopathology is broadly conceived. We shall mean it to include the study of the normal and abnormal personality from birth until death (i.e., developmental psychology). The study of the normal personality as an independent and legitimate area of investigation did not come about until the third decade of the twentieth century. Concern about the abnormal, on the other hand, was forced upon the intelligent consciousness of society centuries ago. It was not until the 19th century, however, that the medical treatment of the mentally ill began to make inroads on the earlier superstitious views of the "insane." The early organic approach to the alleviation of these behavior deviations soon turned out to be inadequate for most cases; this fact paved the way for the understanding of deviant behavior in terms of psychological processes. There was good reason for the neurologically trained psychiatrist Sigmund Freud to switch horses in midstream and turn to a functional rather than an organic orientation in the treatment of neuroses. His psychoanalytic procedures were more relevant to the problems at hand. While psychoanalysis is undeniably overrated as the panacea for the psychological ills of the world, particularly by the cocktail party set, there can be little doubt of the validity and the theoretically integrating value of much of Freud's thought. Freudian adjustment mechanism concepts such as rationalization, projection, sublimation, and repression represent the key to modern thinking about the integration of personality. The stress which Freud and other psychoanalysts put on sex, or inferiority, or compensatory drives, or mystical needs, are undoubtedly oversimplified versions of what motivates people. The important point is that Freud's thinking has moved beyond the dilettante set and is now being appraised by more critical eyes. Theoretical and experimental academicians are attempting to put many of the psychoanalytic concepts to experimental test. The experimental psychiatrist Masserman, for example, has successfully applied some of the therapeutic principles of psychoanalysis to organisms (cats) that had previously been rendered experimentally neurotic. Similarly, the psychologist J. M. Hunt has offered some experimental evidence for the important effect of early experiences on later behavior patterns. It must be candidly admitted at this point, however, that nobody knows how much of psychoanalysis will be able to withstand the test of rigorous observational data. In the meantime the psychoanalytic system and method provides the theoretical and practicing behavior specialist with a reasonable first approximation to an understanding of the motivation and desires of men.

In many ways the study of abnormal behavior has not been very fruitful. Our mental institutions continue to grow in number as well as number of inmates. It is estimated, for example, that in the U. S. there are about 680 mental hospitals and about 9,000,000 people suffering from mental illness and other personality disturbances. This represents about 6% of the present population, or about one in every sixteen people. On any one day in the year, there are about 650,000 patients in mental hospitals; the patients in mental hospitals make up about half of all the patients in all the hospitals in the United States. Furthermore, the intelligence of man does not have too much to say about just what should be done to alleviate the situation. While many neurotic and psychotic individuals have been "cured," little or no insight has been brought to the foreground to "explain" why. Success in therapy, to the extent that it exists at all, is essentially empirical. This is, of course, a proper expedient, but it is not very adequate science. Little, if anything, can be done for most individuals in chronic psychotic states. While physiological and verbal therapies have been helpful, even dramatically so at times, none of these procedures is sufficiently convincing. If they were, the inmates of mental institutions would be leaving in larger numbers. The psychoses have been particularly refractory to scientific investigation, and furthermore, the research money available for the solution of a task as monumental as this has been grossly inadequate.

While the availability of research funds has only improved slightly, with the recent establishment of the National Institute of Mental Health and other government support, the manpower future of clinical psychology looks more hopeful. The Veterans Administration, faced with the problem of having to care for many thousands of mentally disturbed patients, has been subsidizing a rather unusually complete clinical training program in order to meet the continuing shortage of properly educated personnel. Veterans Administration training stipends and supervised hospital internships are available to outstanding students of clinical psychology at many of the leading universities of the United States. The growth of clinical psychology due to this kind of support has been nothing short of spectacular.

It has been estimated that there are around 20,000 words in the English language which have been used to describe personality. This superficial fact, in itself, gives us some idea of the complexity and difficulty of studying the normal personality. Because of this complexity some psychologists have claimed that the area of personality study is simply too broad, that it is essentially identical with the entire field of psychology. After all, intelligence, aptitudes, reaction time, how one perceives, one's emotional make-up, are all aspects of one's unique personality. But these processes are also portions of other, diverse fields of psychology such as experimental and psychometrics. Perhaps the most reasonable basis for independent status lies in the global or gestalt view which the majority of personality specialists take in attempting to unravel the mysteries of their domain. Another basis for independence can be built around the importance placed on personality growth and differentiation. Child studies, such as those of Arnold Gesell, serve as a guide for modern young parents concerned about the normal psychological growth of their children. While adult and old age patterns of development have been studied relatively rarely, the recent interest which psychologists have shown in geriatrics may eventually complete the story which Gesell so ably started.

While the applications of the personality-psychopathology field are primarily clinical in nature, there are other outlets. For example, great interest in the closely allied field of counseling has been shown by both schools and industry. University counseling centers are rapidly becoming an expected service in the more progressive colleges and universities. These centers concern themselves with personal adjustment problems in addition to purely educational or vocational guidance problems. Setting up a service for the handling of "personality" problems has also received the careful consideration of top industrial management officers. Perhaps the most famous example of this was the introduction of a counseling center in the Hawthorne plant of Western Electric Co. about two decades ago. While an enlightened business management policy of this type is still relatively rare, inroads have been made, and there are definite signs that industrial counseling programs are on the increase. Clinical psychology itself has, of course, taken off in many directions. While it is practiced most extensively in state mental hospitals and V.A. hospitals, many outpatient mental hygiene clinics and child guidance centers have been developed in recent years. Furthermore, the concern of the public schools for the mental as well as the physical health of the child has increased. This has resulted in the certification of school (clinical) psychologists in many states.

SOCIAL PSYCHOLOGY

The basic unit of psychological study is the individual organism. The basic unit of sociological study is the group. Social psychology is a true interdisciplinary field which is concerned with the individual as a part of the group. The earliest investigations in this area were largely concerned with the behavior of relatively large groups. The psychology of masses, the why and wherefore of crowd behavior, and observations on conformity behavior were important empirical studies. It was not until two decades ago, however, that true laboratory experiments were carried out in this field. This was first demonstrated convincingly by Sherif, who used the traditional autokinetic phenomenon as a point of departure for making controlled observations on the effect of social pressure and prestige on personal judgments. The autokinetic effect involves observing a stationary pinpoint of light in a completely darkened room. Most people report some movement of the light source in spite of the fact that it does not actually move; hence the name, autokinetic, or self-movement phenomenon. Sherif extended this typical laboratory set-up by recording the difference in extent of movement reported by subjects under a variety of social conditions. For example, Sherif noted that subjects tended to report extent of movement in accordance with a group norm. If most of the group reported a lot of movement the remaining individuals also reported considerable movement. If most of the reports presented in the group session involved a relatively small amount of movement, so did the remaining reports. At other times Sherif introduced a prestige factor. Say ten subjects in a group had already established their individual and group norms concerning perceived movement and that the group norm was essentially that there was little movement. Sherif would now bring in a new subject of considerable local or national prestige, say the President of the college or the Governor of the state, and record the movement perceived by this new subject. If the "prestige" subject reported a great amount of movement, so did the ten individuals of the original group in subsequent reporting trials. In other words, Sherif has offered us clear-cut evidence for the importance of social norms in the determination of personal judgments.

The importance of group norms had been pointed out earlier by the cultural anthropologists. Franz Boas, Margaret Mead, and Ruth Benedict were struck by the importance of cultural and social factors in the determination of personality as a result of their extensive field studies on primitive societies. This anthropological type of study was undoubtedly stimulated by the extremist position which theorists such as McDougall and other social psychologists had taken in the early nineteen hundreds. McDougall claimed that social behavior was not learned. Long lists of "social instincts" were prepared by way of explanation for such things as aggressiveness, gregariousness, acquisitiveness, and self-assertion. The studies of the cultural anthropologists clearly showed that these social expressions were learned, and furthermore, that they were passed on to the individual by way of the culture and subcultures. In one cultural group perhaps aggressiveness would be played up as a desirable social norm; in another culture just the opposite would be the case. Ruth Benedict's book, *Patterns of Culture*, is a well-written account of the importance of these cultural differences in the determination of the personality of three very different peoples, the Pueblo Indians of New Mexico, the Kwakiutls of the Northwest, and the Dobuans of New Guinea. The Pueblos are described as being essentially self-effacing, the Kwakiutls as being concerned with glorification to the point of megalomania (definitely abnormal as viewed from our cultural standards), and the Dobuans as being a treacherous, and even murderous, lot.

The importance of cultural relativism to the understanding of human behavior cannot be overestimated. And, just as large groups, such as nations, or Western or Eastern civilizations, set the patterns by which people live, so do various subcultures serve as important determinants of behavior. This line of reasoning carries us right down to the small group kind of research which Sherif conducted in the laboratory. It also delineates a very important trend which was given considerable impetus by the late Kurt Lewin during the last two decades of his life. While he was at the State University of Iowa he conducted an important series of studies on what he called "social climate." He showed, for example, that greater productivity resulted from a boy's club which was led as a "democracy" as opposed to the productivity of the "laissez faire" or "autocratic" groups. This trend carries the name of group dynamics, and is currently one of the most active research areas in the entire field of social psychology. The Research Center for Group Dynamics, a large research institute first established at Massachusetts Institute of Technology by Lewin, and moved to the University of Michigan after his death, is the major source of research of this kind.

The practical implications of fundamental research on social psychology are potentially of greater significance than perhaps any of the other areas of psychology. Since all humans live in a social matrix from birth until death, the applications to everyday living are legion. Getting scientific answers to various psychological problems concerning racial differences, for example, would contribute considerably to international good will. More accurate knowledge of the social psychology of man could even contribute to the solution of man's most difficult world problem today — how to control the tendency toward war. Public opinion polling has obvious implications for the political life of the world as well as implications for business. The very same sampling, attitude scaling, and questionnaire techniques are used in both areas of application. The determination of attitudes by a team of social psychology experts was of considerable relevance to morale problems in the armed forces during World War II. As a matter of fact, an extensive attitude survey was actually used as the basis for establishing the discharge policy in the Army and the Air Force at the end of World War II. Similar polling procedures are used in enlightened business establishments. Many government and industrial organizations initiate their personnel overhauling procedures with an attitude survey. It provides an excellent method for identifying "problem" areas which need improving. Literature on the psychology of leadership was non-existent ten years ago. The crucial need for combat and administrative leadership in the mammoth expansive operation of World War II pointed up the complete void in our knowledge of this area. During the war studies on combat leadership were initiated and, in some cases, observations were made under actual combat conditions. The post-war series of studies which have been conducted at Ohio State University are an important contribution to the eventual solution of leadership problems. Psychologists have not been too vocal in the areas of penal and legal psychology. It is to be hoped that there will be sufficient advance in the fundamental knowledge of social psychology during the next few decades so as to provide the practicing social psychologist with sufficient ammunition to effect a change in many of the essentially archaic practices in the handling of criminals. Until psychology can prove itself more precisely in these matters, however, the legal profession cannot be expected to throw over the inherited practices of time for a new set of "questionable" procedures.

CONCLUDING REMARKS

Within necessary limitations of space, we have tried to provide a panoramic view of psychology in mid-twentieth century. As has been seen, the area that psychology includes is vast. It covers the spectrum from the physical sciences, through biology, to the social sciences, and has amassed literally mountains of empirical data. If we look at the absolute number of incontrovertible facts and valid generalizations concerning behavior, or if we contemplate in what ways psychology has helped us to "understand" human nature thus far, we are not particularly impressed. On the other hand, if we contemplate what we knew about behavior in 1880 with what we know now, the extent of our progress is quite staggering. More important, perhaps, is the fact that we have firmly brought in the scientific method where it previously was not allowed. In about seventy-five years we have moved away from the habit of philosophizing about the nature of "mind" to a fairly healthy state of setting up observations and experiments when we want to put questions to human nature. It seems reasonable to predict that this stress on experimentation will continue to be the key activity of the psychologists of tomorrow.

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9

The Basic Postulates of Psychology

W. EDGAR VINACKE

In contrast with Dr. Kimble's article which follows this one, and presents a particular theoretical point of view about (or a "way of looking at") behavior, Dr. Vinacke is concerned with *the* psychological viewpoint — those common working assumptions which he believes are accepted by all psychologists. The reader may be interested in relating Dr. Vinacke's thirteen postulates to the sections of this book. For example, postulate 9 is clearly concerned with Part III, postulates 1 and 3 with Part IV, and so on.

After receiving his PhD at Columbia University, Professor Vinacke followed a career in research before joining the faculty of the University of Hawaii in 1946. He is currently studying the psychology of thinking and problem-solving. The article which follows originally appeared in the August, 1948, issue of *Scientific Monthly* (pp. 110–114), and is reprinted by permission of the publisher and the author.

The science of psychology has been developing and growing for almost seventy years. Its origin, in modern terms, is generally dated from the year 1879, when Wilhelm Wundt established the first psychological laboratory at Leipzig. That historic event marked the culmination of a long gestation, during which psychology was grown out of physics, physiology, philosophy, and even astronomy. Wundt started psychology off on its extensive experimental career, but the psychology of today would hardly be recognizable to him and his colleagues. A great deal of the period since 1879 has been devoted to controversy, as everyone knows, between a succession of comparatively narrow viewpoints. The most famous of these in America are existentialism, functionalism, behaviorism, and gestalt psychology. Psychoanalysis and related schools should be added to this list, although they were developed by psychopathologists, since they have profoundly influenced (and frequently annoyed) psychologists of all kinds.

It is not my intention to review these controversies. That has already been well done by half a dozen psychologists. Such writers usually end by pointing out that each school makes its valuable contribution, but that most psychologists are eclectics and do not subscribe to any single viewpoint. They suggest that the future will evaluate various theories and ultimately combine them into a unified system. Perhaps the time has come to begin this task. This article is an attempt to formulate the main outlines of psychological thinking as it exists today, not with respect to specific problems, but in terms of the axioms, so to speak, that have become established during its formative period. Students in psychology classes frequently worry over the apparent lack of agreement among psychologists, and other scientists have reactions varying from amusement to disgust in this regard. My thesis is that, actually, all modern psychologists stand on approximately the same general platform, which may be called the "psychological viewpoint."

It is to be hoped that the formulation of this viewpoint will serve a double end. On the one hand, it may indicate that there *is* a "psychological viewpoint," the fruit of past thinking about human behavior. Thus, other scientists may come to understand better what psychologists are thinking nowadays. On the other hand, it may serve the function of an examination of where we stand on historical issues.

Many omissions will probably be evident. Some, to be sure, are intentional, either because no general agreement as yet exists or, perhaps, because psychology today does not deal with such matters. Running the risk, then, of incompleteness, the following postulates are advanced to define the modern "psychological viewpoint."

I shall develop thirteen general propositions which seem to me to characterize modern thinking in psychology.

Postulate 1: *The material of behavior.* The same fundamental variables are present in the total behavior of all human beings, although all degrees of these variables may be observed; differences between individuals are largely differences of degree rather than of kind.

The foregoing postulate is not intended to convey the idea that all people are alike; far from it. Apart from the fundamental variables, of course, there are innumerable other variables that may be unique to an individual, a group, a sex, or a race. The argument, on this point, largely concerns the formulation of what constitutes a basic variable. The problem is to isolate and state these variables in cooperation with the other sciences of man.

For the present purpose, a fundamental variable may be regarded as a broad, generalized determinant of behavior in the organic structure of man, or in the world that confronts him, or in a relationship between organism and world. A fundamental variable is, so to speak, a starting point of behavior.

The main point here is that psychologists think in these terms. Glance at any of the leading textbooks in introductory psychology. One finds treatments of a wide range of subjects, from emotion and motivation, through sensory processes and perception, thinking, learning and memory, etc., to individual differences and personality. In all these the assumption is tacitly made that, although people differ, they all function in the same general ways and face essentially the same problems.

The following examples illustrate this basic feature of psychological thinking:

(*a*) *Organic drives.* Although no final list of organic motivating factors has been presented, and although different terms are used for the same phenomena, we can say that the sex, hunger, thirst, and oxygen-inspiration drives are universal, leading to positive approaching behavior. Contrasted with these are others leading to negative activity, such as excretion and avoidance of injury. The ultimate role in individual behavior of such drives is another matter; at least they enter into the development of each individual to some extent. They are starting points on the organic side of long chains of behavior processes.

(*b*) *Group adjustment and institutionalized behavior.* All individuals are confronted by other people and organized group codes, if only during the helpless period of infancy. All individuals are influenced to some extent by these factors. The fact that established codes or norms confront the organism is a starting point on the side of the external, real world.

(*c*) *Learning, memory, and higher thought processes.* All individuals are modified by dealing with the environment, retain some, at least, of this experience, and make use of it in dealing with later problems. Apparently, some specific laws can be stated in this connection, such as that forgetting is most rapid immediately after learning, and then slower; and that two tasks done in succession and similar to each other are less efficiently learned than two dissimilar tasks done in succession.

(*d*) *Sensory processes.* All people possess variations of the same general sensory functions within quite specifiable limits. Thus, the range of human hearing is 20–20,000 cycles per second, and the average reaction time to a visual stimulus is 200 ms, which is somewhat slower than reaction time to sound. (In this discussion, we have not considered some special qualifications, as with regard to feeble-minded or other exceptional persons who would represent the extremes. *Cf.* Postulate 3.) Examples *c* and *d* represent factors of organism-world relationships as determinants of behavior.

Postulate 2: *Uniqueness.* Every individual, as a total personality, is different from every other individual, as a result of past experience in conjunction with heredity, because no combination of factors is ever precisely the same for any two individuals.

The foregoing axiom is not a contradiction of the first, but a further, and essential, development of it. The chief argument is the dividing line between an individual and general characteristic, or how general a psychological law can be. As G. W. Allport has pointed out, "A general law may be a law that tells how uniqueness comes about." The latter kind of law is necessary, as the modern and complex study of personality is repeatedly demonstrating.

We can say that psychologists do not ignore the uniqueness of the individual, even when thinking in terms of Postulate 1. They recognize that the interplay of basic behavior variables, cultural and group influences and disciplines, and "accidental" situations and experiences add up to unique total personalities, if only because the combinations and permutations are so enormous in number. This feature of the psychological viewpoint is a prime reason for the inclusion of long chapters on personality in modern textbooks, which are otherwise framed in terms of Postulate 1. The more advanced student is far more extensively indoctrinated in terms of Postulate 2. The modern development of the field of personality is largely concerned with it.

Postulate 3: *Normality.* "Normal" behavior is a relative matter; it is that behavior which characterizes most people within a given cultural group (with certain privileged exceptions, such as the artist). "Abnormal" behavior is extreme deviation from a given average point in terms of a defined variable, or group of variables.

This postulate is primarily statistical. It explodes the fallacy that people are separable into distinct types (a feature of naïve, everyday thinking, by the way) and states that people who differ widely, say, in introversion-extroversion, are simply extremes of a continuum where most people are neither markedly "introverted" nor markedly "extroverted." In other words, the normal probability distribution is now regarded as characteristic of most, if not quite all, psychological variables.

In discussing "normal" people, therefore, the psychologist is making no qualitative distinctions, but is simply dealing with the average person. Since it happens that modern psychology is primarily a development of Western culture, we should qualify Postulate 3 in terms of its frame of reference. Implicitly, the American psychologist is thinking about that behavior characteristic of most American individuals (in terms of Postulate 2 — i.e., over and beyond the fundamental variables). It would be a valuable project for a group of Hindu or Chinese psychologists to develop a normal psychology of Hindu or Chinese people. To some extent this kind of development is no doubt occurring in Soviet Russia. In any event, it is evident that normality, as we have defined it, may be very different in different cultures.

The concept of "abnormality" is a corollary of that of "normality." It is that behavior which deviates to an extreme degree from the average, whether with respect to intelligence, adjustment to the group, emotional-motivational behavior, etc. The "abnormal" is therefore only an arbitrary and fairly extreme distinction from the normal.

Postulate 4: *Physiological concomitants.* Every manifestation of behavior in an organism (here, the human being) occurs in association with some physiological change; no human behavior can take place without some change in the organism.

Not much comment is required here. Stemming largely from the arguments of the behaviorists, modern psychological thinking rests upon the assumption (as yet it is often only an inference) that the organism functions in terms of its structure and the properties of its organized tissues. Even a thought, however original or untraceable in origin it may seem, nevertheless depends upon some activity of the nervous tissues. Even an emotional impulse is somehow a chemicophysical response.

Postulate 5: *Heredity-environment.* The human organism, like all living things, is the joint product of heredity and environment; no aspect of the behavior of an individual is entirely independent of either heredity or environment.

One of the great controversies in psychology, and one vital to most psychologists, concerns the contribution to behavior of "nature" and "nurture." In a sense, there are two aspects of the problem. On the one hand, the effects of hereditary and environmental factors on behavior may be rather neutrally examined; on the other, an inevitable assessment may be made of their relative importance. In any event, despite wide divergences of opinion on the latter point, nearly all psychologists today recognize the joint contribution to development of both factors. If the current standard textbooks be regarded as representative of psychological thinking, Postulate 5 must be regarded as valid.

Evidence for the truth of Postulate 5 is singularly difficult to obtain, to be sure, because of the difficulty of controlling and measuring the development of human beings. One of the wisest and most careful of psychological observers, R. S. Woodworth, has made an admirable study of the evidence. Reviewing the studies made of twins (identicals and fraternals), foster children, and children in institutional homes, he presents a clear analysis of the present status of the problem. The total picture is one of the inseparability of hereditary and environmental factors. In any event, we cannot now say that either heredity or environment is *the* important factor in development. Both jointly determine ultimate behavior, in a complex interaction, in a multiplicative (since neither can be zero) rather than additive sense. It must rest here until further work has been done.

Postulate 6: *Socialization.* Human behavior of any sort can be fully understood only in terms of the social context in which it developed and in which it functions.

It is in connection with this postulate that the anthropologists have made the most valuable contributions to psychological thinking. As was noted under Postulate 3, general psychology frequently takes the social context for granted, simply because it is common to both psychologists and students. In the fields of personality and social psychology, however, it cannot be tacitly assumed, but must be examined. The result is that "human nature" is shown not to be more or less the same the world over, but that the human individual is a complex "organism-in-society." Hence, the current interest in attitudes, for example, as one area in which the dependence of the individual upon his society is most readily (although not easily!) studied.

Postulate 6 may not seem to harmonize with Postulate 1, but there is no actual contradiction. In Postulate 6 we are dealing with activity in progress, so to speak, and the behavior that develops during the life history; in Postulate 1, we dealt primarily with the starting points of behavior, which are quite rudimentary and largely undetermined in their ultimate direction and expression.

Psychologists nowadays have learned to be cautious in ascribing to "human nature" any aspect of behavior without at least taking account of the implications of Postulate 6. Indeed, they have criticized Freudian psychoanalysis in precisely these terms. They beware, now, lest ethnocentrism of any variety befuddle their thinking.

Postulate 7: *Objectivity.* No interpretation of human behavior can be fully accepted unless it is founded on fact substantiated by scientific evidence.

No particular comment is necessary. Today's psychologists, keenly aware of the difficulties involved in the study of behavior, and strongly influenced by the standards of other sciences (more so, sometimes, than scientists in those other fields), think in careful methodological and evaluative terms. They beware just as much (more, in fact) of egocentrism as of ethnocentrism. True, there is still a long way to go, but every modern reputable psychologist receives intensive training in terms of Postulate 7. The behaviorists are especially to be thanked for this trend.

Postulate 8: *Finality.* In the study of human behavior, no interpretation, conclusion, or law is necessarily final, but is given in the light of the best present knowledge; allowance must be made for the possible operation of unknown or uncontrolled variables, and for other possible limitations of knowledge or outlook.

This statement, also, requires little comment, since it is no doubt basic to all fields of inquiry. It means that psychologists, on the average, do not pretend to have all the answers. They continually strive to improve their methods and to push further the frontier of our understanding of man; they continually examine and retest their existing experimental results and theoretical formulations. Psychologists are still hazarding hypotheses and conducting investigations. Psychologists are no more complacent, arbitrary, or pedantic than other scientists, who also retain a sense of curiosity, of criticism. The realm of understanding has not yet been conclusively defined.

Perhaps more than any other, Postulate 8 is the reason for writing this article. It reflects the fact that in the history of psychology we have often had to change our interpretations of behavior as new facts and theories emerged. Thus, it becomes valuable, as in the present instance, to formulate our position as of the present. But it is not necessarily an absolute or final formulation. The psychology of the future may force us to revise or reject our basic postulates or to add new ones.

Postulate 9: *Modification.* Human behavior is not static; the individual develops and his behavior is modified and remains modifiable as long as life continues.

Modern psychology, with its intense emphasis on learning, development, and activity, would not be recognizable to psychologists of fifty or sixty years ago. No modern psychologist thinks of a human being as a static, largely unvarying thing, to be described in terms of sensations, images, feelings, and ideas. Instincts, as universal, fixed determinants of behavior, have been rejected. Even if certain innate forces do exist, it is now being shown, even in lower animals, that they are modifiable when conditions change.

Similarly, the relationship between childhood, adolescence, and adulthood is now continually emphasized and studied. Nor is prenatal development ignored. Modern psychology is no longer that of an adult (primarily male), of twenty to forty-five years of age, who resembles a mounted specimen in a museum showcase. Rather, man is studied in terms of continuous growth and function, literally from conception to death. Thus, even when adult behavior is the focus of attention, it is not considered to be rigid, and senescence will become an important field of research in the future.

Postulate 10: *Measurement.* Potentially, all human behavior can be measured and described.

This postulate implies that, however mysterious some aspects of human behavior may be, they are ultimately understandable in scientific terms. All too frequently, the modern psychologist must qualify his interpretations with the statement "We are not yet sure," or "That has not yet been determined." However, most psychologists are certain that sooner or later investigation will uncover the still-hidden facts of behavior.

Postulate 11: *Diverse views.* Human behavior may be, and has been, interpreted from different viewpoints, no one of which is necessarily right or wrong, and all of which may contribute to complete understanding.

Postulate 11 is the modern eclectic viewpoint and reflects a moderate approach to the assertions and theories of different "schools." Glance through any standard textbook on psychology or the bibliography of almost any article that deals with a general problem. It will be apparent that all the "schools" are represented. In the former case, the history of the great controversies is presented in disguised form. For example, the chapter on motivation and personality will reflect psychoanalytic contributions; the chapter on learning will probably owe much to behaviorism; the chapter on sensory processes can be traced, in part, to Titchener; and the chapter on perception will lean heavily on gestalt psychology. Even William James will enter into the discussion, at least in the chapter on emotion. It is no wonder that the modern psychologist thinks in terms of Postulate 11. He is historically determined, as E. G. Boring has sagely pointed out.

Postulate 12: *Fractionation.* If, for convenience, aspects, or parts, of human behavior are studied separately (or if apparently divisible units are analyzed), it cannot be fully understood or described in terms of these elements, but must finally be viewed as a whole organization.

The above statement sums up the most significant contribution of the gestaltists to psychological thinking. So insistent have they been, and so articulate, that psychologists of the present think less in terms of units (such as sensations, images, and conditioned reflexes) and more in terms of patterns and sequences. No aspect of behavior is seen as separate and distinct from other aspects; the activity in progress at the moment is viewed in relation to the total state of the organism, as organized on the basis of past experience, other current functions, and even, when necessary, foresight or planning for the future.

Although the gestaltists have dealt most extensively with visual perceptual processes, psychologists have been markedly influenced by them in other connections also. Referring once more to standard texts, one would find in nearly every chapter sections devoted to the relationships between diverse phenomena, functions, and activities. There would be found many cautions against fractionating behavior, toward the end of showing the total individual, not as a sum of elements, or a composition of units, but as a complex interrelated organization of continuous patterns, functions, and processes.

Postulate 13: *Dynamics*. All human behavior has a cause.

Freud contributed to psychology, as much as anything else, the important viewpoint that mental processes, emotional impulses — indeed all activities — are dynamically caused, that there is a reason for their occurrence. No matter how irrelevant, accidental, or inexplicable a person's behavior may seem, it does not occur simply at random, but stems from some actual, though perhaps concealed, source within the individual. Psychologists now appear to accept this idea.

Postulate 13 may, perhaps, be regarded as a correlate on the psychological side of Postulate 4.

In the foregoing discussion I have endeavored to set forth the broad outlines of the current psychological viewpoint, with some measure of historical perspective. The era of "schools" is about over in psychology, as Keller observes. The eclectic psychologist no longer troubles himself very much with them, save in historical surveys, and the standard textbooks represent fairly well a synthesis of them. I believe that the average student now gets substantially the viewpoint presented above.

This article is designed to present the broad framework of this thinking for the consideration of other scientists. All too often there is doubt as to what it is, and whether any progress has been made. Actually, psychology has shown a healthy development, as a result of a vast and lively body of experimentation and systematic thinking. Nor has this growth displayed the slightest sign of diminishing return. On the contrary, these paragraphs may be regarded as the discussion of a temporary condition, really the bare minimum of conceptualization in psychology as it exists today.

10

Psychology as a Science[*]

GREGORY A. KIMBLE

Dr. Kimble carries the comparison of philosopher and scientist down to specifics, and in doing so emphasizes the role and activities of the behavior scientist in particular. He distinguishes between two kinds of behavior laws which the psychologist strives to establish, and discusses the systematic organization of laws into behavior theory. Although the particular theoretical position which he favors is widely accepted among psychologists today, it is not universally accepted. It is sometimes criticized for considering the individual as an "empty organism." Many different theories have been proposed, and it is perhaps too early in the history of psychology to know which will survive.

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[*] This (somewhat revised) is a paper read before the Rhode Island Philosophical Society at Brown University in 1949. Its purpose is to present in simple language the ideas that are basic to modern behaviorism. A more technical development of these ideas (and probably some of the happier phraseology) can be found in the writings of Bergmann and Spence. The sophisticated reader will note that this account underemphasizes the deductive aspects of theorizing. The omission does not mean that I regard this process as unimportant. It means, instead, that the purposes of this paper could be achieved in a more straightforward manner by stressing less technical matters. I am indebted to Professor Bergmann for reading an earlier version of the manuscript, and to Professor C. J. Ducasse of Brown University, whose interest in and criticisms of this paper have led to a number of basic improvements.

The author is associate professor of psychology at Duke University and has previously taught at Brown and at Yale universities. His article originally appeared in *Scientific Monthly* for September, 1953 (pp. 157–160), and is reprinted by permission of the publisher and Dr. Kimble.

The approach I would like to take to this discussion of psychology as a science is simply that, whether or not such is generally the case now, it is possible to approach the problems of psychology scientifically. Furthermore, it seems to me that about our only hope in this task lies in making use of the things that the philosophers of science are able to tell us. I have, therefore, tried to decide just what lessons these philosophers can teach us and how they can be applied to psychology. My sincere hope is that the summary of my thinking on the topic which I am about to present does not do the philosophers too great an injustice, or, if it does, that they can at least be philosophical about it.

Let us begin by stating the subject matter with which psychology deals. The standard definition of psychology is that it is *the science of behavior.* This definition probably needs clarification. On the one hand it covers less than you may have expected. On the other, it covers too much. Note first that the definition says nothing about mind, or experience, or consciousness. This is not merely an attempt to finesse the problems raised by these three terms. If they are to be used at all in a science of psychology, they will have to be introduced in a way to be described later. A second point is that the behavior with which the psychologist deals tends to be limited to its grosser aspects. Where internal physiological processes are a part of psychology, they are conceived as aids to conceptualization rather than as a part of its basic subject matter. I shall return more than once to the question of the relationship between psychology and physiology; let us turn now to a discussion of the use of the term, "science," in the expression, "science of behavior."

The word, science, refers to the attempt that people called scientists make to bring order into the world of observable events. Scientists are, of course, not the only ones trying to bring order into the world. Others are the theologians, some literary people, and the philosophers. The scientific way of approaching the task differs from these latter ways, chiefly in terms of its initial data. All science begins with the sensory experience of a perceiving scientist. These sensory experiences, which are private and not a part of science, give rise to its initial data, that is, to a publicly observable *report* of such experiences. In this sense, psychology is exactly like any other science. The report with which psychologists are provided may be about rats running a maze, physiological processes, test results, or even the scientist's own introspection. But the element of all of this that is useful is the report that is open to public inspection.

The particular task which the psychologist has taken for himself is that of trying to make some sense of behavior. But we have just seen that, as scientists, psychologists must concern themselves with events that are publicly observable and, therefore, verifiable. This restriction on the activities of psychologists raises a question: Just what kinds of observations can they make on behavior that are of this sort? The answer to this question comes in two parts. First, psychologists have found (just as other scientists in other fields have found) that human behavior is so complicated that it is impossible even to talk about all of the activity of an individual at any one time. So, in practice, they restrict their observation to limited portions of behavior called responses. Second, even responses cannot, without the aid of photographic assistance, be recorded in detail. So, their reports of behavior typically deal with some abstracted characteristic like the speed or the magnitude of the response.

Having stated the general manner in which the psychologist views behavior, a word must now be said about a primary assumption, which is that these various aspects of behavior are related to events in the person's past and present environment. Although the collection of variables in this category might better be called antecedent and attendant circumstances, the psychological convention is to call them stimuli. When the psychologist speaks of stimuli he usually is referring more or less broadly to events or changes in events in the environment. So far as these stimulus variables are concerned, they are so numerous that no attempt to enumerate them here is possible. A few examples will have to do. In the field of learning, for one example, the efficiency of a learned reaction is known to depend in a regular fashion upon the number and spacing of practice trials, upon the amount of reward the subject is given for making the response, and upon many other variables. In vision, what a person sees (really what he *says* he sees) is known to depend upon the area of the visual stimulus, upon its brightness, upon the duration of its presentation in the visual field, and so on. One thing that should be noticed about these particular examples of environmental events is that they are quantifiable in terms of some standard physical measuring scale. Not all variables with which psychologists have to deal are yet subject to measurement in any very respectable sense of the word. For the kind of information that is needed to build a science of psychology, however, quantification of these independent variables is a necessity of which psychology is acutely aware.

The final task in the development of a behavior science is simply that of stating the relationships that exist among the variables that have been isolated. What psychologists are after is a set of laws of the general type: $R = f(S)$, where R is some aspect of a response, S is a stimulus event and f represents the functional relationship. These are what I will call *S-R* laws. It should, of course, be realized that the formula, $R = f(S)$, is highly schematized. Behavior is seldom predictable from knowledge of a single *S*-variable. The *S* in this equation stands for an indefinite number of antecedent conditions which in actual practice will have to be discovered along with their relevance to behavior.

Because of this complexity in the determination of behavior, the *S-R* laws have turned out to be very difficult to discover. Where this has happened, psychologists have sometimes had more success using a different approach, in an attempt to discover the relationships that exist among *response* variables. As a convenient example of this, one may take the very important work of the clinical psychologists and the psychological testers. They almost never deal with the *S-R* type of relationship at all. Instead they use what are sometimes called *R-R* laws. The distinction between these two types of relationship is shown in the following example. There is some rather good evidence to suggest that an individual who is frustrated in his various strivings develops a tendency toward aggressive behavior. For purposes of exposition, it can be assumed that this is a well-established relationship. On this basis, if one knew that an individual had been frustrated many times in his efforts to achieve important goals, it could be predicted that he would show aggressive behavior. In this case, an *S-R* law would be used to make the prediction. The determining *S*-variable is the frequent blocking of goal-directed behavior, and the dependent response variable is the aggressive behavior. If it were known that aggressive behavior in some form always occurs as a consequence of frustration and that it never occurs in the absence of frustration, there would be some point in saying that aggression occurs *because* of frustration. Furthermore, given a control over the person's environment and a knowledge of the *S-R* law, the amount of his aggressive behavior could be controlled.

A clinical psychologist, on the other hand, might give this same person a psychological test and come out with the statement that he has strong aggressive tendencies and may be expected to show a great deal of hostile behavior on many occasions. This prediction (which would be as correct as the other one) would be made in terms of a different kind of law. What the clinician has done is to observe a small segment of the individual's behavior in a controlled situation called a test, and, from his behavior in this situation, to make a prediction about other behavior. His prediction is made in terms of an $R_2 = f(R_1)$ kind of relationship, in which R_2 is the predicted aggressive behavior, R_1 is the predicted-from-test behavior, and the function is a correlation coefficient. These *R-R* laws are diagnostic laws, and carry no implications of causality. (The statement that the person tested is aggressive because the clinician has given him a test is obviously absurd, at least until such a time as the clinician's services are more expensive and, therefore, more frustrating than they are now.) Furthermore, the *R-R* laws provide no control over behavior in the absence of further information of the *S-R* type.

The commodities in which the psychologist deals are, then, two types of relationship which I have called *S-R* and *R-R* laws. The precise statement of a large number of such laws would be extremely valuable, but it would not make psychology a high-order science. What would still be needed would be the collection of the *S-R* and *R-R* relationships into some more orderly or integrated kind of formulation. In actual practice, it has been found useful to attempt the formulation without the comprehensive set of empirical laws it is hoped eventually to integrate.

Such attempts at formalization are called systematic psychology or psychological theory.

The form that psychological theorizing has taken has been toward the development of intervening state variables which are considered as standing between S and R or between R_1 and R_2, depending upon the kind of relationship. The intervening states that have been postulated have been of two general sorts, physiological states and hypothetical constructs. If we consider first the type of intervening variable used by the more physiologically minded psychologists, the paradigm in terms of which they attempt to explain behavior may be expressed in the following way: *S-O-R*. Stimulation according to this scheme is thought of as producing some physiological or organic change in the individual. And this physiological change, in turn, is thought of as being responsible for whatever behavior is being observed. Such psychologists investigate the relationships between neural, glandular, circulatory, and muscular events, on the one hand, and behavioral events on the other.

Another large group of psychologists make use of the hypothetical construct type of intervening variable in their explanation of behavior. The paradigm, in terms of which such psychologists work, is the following: *S-H-R*. Antecedent stimulus conditions are thought of as defining a hypothetical intervening state in terms of which responses are predicted. Examples of such hypothetical constructs in fairly general use are: habit, motivation, fatigue, attitude, symbolic processes, and the like. About these hypothetical constructs, there are a number of things that need to be said. The first of these is that there is no reason in the world to assume that they *must* have any actual existence inside the organism or anywhere else. Some of them, at least, are analogous to the physicists' concept of velocity which derives its meaning from its definition: $V = S/T$. The physicists do not spend much time worrying about what or where velocity really is. Psychologists, on the other hand, spend a good bit of time looking for the neurophysiological events which they think *have* to exist and to correspond to their concepts, however imperfect. What is worse, they spend even more time speculating about them. There are just two comments that I wish to make about this. One is that, although all behavior probably has its neurophysiological aspects, mere speculation about them is a fruitless procedure. The other is that, although physiological *information* may someday turn out to be useful for psychology, there is nothing in the program of psychology which makes such information indispensable. For all practical purposes, it is possible to construct a science of psychology in which the organism is considered as empty. For my own part, I can conceive of a psychology based on stimulus and response events entirely, one in which the existence of the organism is a completely unimportant fact. The scientific account will, after all, deal with behavior in the abstract. Such a science no more needs to refer to the organism than the science of gravitation needs to refer to stones or to the Leaning Tower of Pisa.

Whether the constructs that are introduced between stimuli and responses are physiological or purely hypothetical, they have to meet certain criteria to be acceptable. The most important of these criteria can be summed up in one word: *meaningfulness*. Intervening variables must be meaningful in two ways. The first is what has been called *operational meaning*. The meaningfulness of a concept in this sense depends upon the adequacy of its definition. A concept may be said to be adequately defined providing there exists a set of defining statements for it which lead eventually to phenomena in the sensory experience of the scientist, and providing further that these statements are such that any properly qualified and equipped person can put them to a test. This requirement is no more than a particular application of the more general criterion of public observability.

Concepts for which no such definition is *possible* are of no use to science. This is not, however, to say that concepts which have never been adequately defined never will be. They may or may not be. Concepts such as mind, consciousness, and experience are in the class of intervening variables for which no satisfactory operational definition exists. This is in part because of the complexity of the phenomena involved, and in part because of their inherent privacy. But this state of affairs does not demand the conclusion that respectable definition is impossible.

On the other hand, an operational definition of these terms (assuming it is achieved) does not guarantee their utility. The second kind of meaningfulness remains to be demonstrated. This point can be made clear with the aid of an illustration. I can define a construct as follows: Kappa (for Kimble) = the square root of the number of hairs on my head divided by my diastolic blood pressure minus the length of my great toe. This concept, Kappa, although its operational definition is impeccable, has not been used much in psychology because, so far as we know, it has no meaningful relationship to any of the events with which psychologists are supposed to be dealing. In this second sense, a concept is meaningful if it is related to behavior, or aids in its prediction.

Just as there are two major kinds of laws with which the psychologist deals, there are two kinds of operations in terms of which a concept may acquire operational meaning. The first of these is by definition in terms of antecedent stimulus conditions. The second is by an inference from behavior. To illustrate, let us consider a case in which both types of definition have been used and return to the example of aggression. It has already been pointed out that predictions of aggressive behavior might be made either from a knowledge of an individual's history of frustration or from his behavior on a test. Using exactly the same evidence, there can be developed two different definitions of the concept aggression. In terms of antecedent conditions, aggression can be defined as a positive function of the number of frustrations a person has experienced. In terms of behavior, it can be said that a person is aggressive if his pattern of test responses is so and so. The one thing we cannot say is that we now have two different definitions of the "same thing." Different definitions define different concepts. In psychology, especially, there is the need to be cautioned against the tendency to treat things as identical just because they have the same name. Whether the frustration-produced aggression has anything to do with the test-defined aggression is an empirical question which can be decided by research.

As I see it, just one final point needs to be made with respect to the science of psychology as it is developing. It must be presented as a sort of confession. Not all psychologists agree with the analytical, behavioristic (what James would have called "tough-minded") sort of analysis I have been presenting of the field. In psychology, we hear a great deal about "the total situation," "the whole child," "the whole personality," and "global intelligence." Psychologists who use these expressions object to the type of account I have given, chiefly because of the analytical approach which it implies. This cold analysis, they say, is wrong because it fails to capture the warmth and vitality of human behavior as we know it in our common-sense, firsthand experience. Unfortunately for common sense, that is how it is with science. Common sense tells us that the world is flat; science says that it is round. Our firsthand experience tells us that the sun moves slowly around us; science says that we are moving around the sun, and at a breakneck speed. Direct observation tells us that the chairs in which we are sitting are solid; science says that they are mostly empty space. The mere fact that some line of scientific argument produces a description of the world that fails to correspond to our naïve experience of it is no obstacle to that argument. And if there are aspects of behavior that cannot be handled in the way I have been describing, I know of no way of finding this out without giving it a try.

At a somewhat different level, the opponents of behavioristic psychology sometimes object that the analysis of behavior destroys its essentially continuous or integrated character, and robs it of its wholeness. They now propose what they call a field theoretical approach to human behavior and very bitterly deplore what they call the *mechanism* of the sort of argument I have been expounding. They say that their new field theories stand to the more orthodox psychology as does the theory of relativity to Newtonian mechanics. The adequacy of this analogy, of course, depends upon some understanding of what the term, "field," means in physics. It seems to have been used in two rather different ways. Basically, by a "field," the physicist means a system of interrelated variables that differs from other systems of physics partly in the kind of calculus which expresses the interdependencies. Unfortunately, the mathematics are difficult, even for a physicist. So, for their nonmathematical brethren, the theoretical physicists have constructed models (as, for example, the Rutherford-Bohr atom) in an attempt to convey what is involved in their equations. Since the so-called field theories in psychology consist of anthropomorphic models in this second sense, it seems to me that they cannot be called field theories in the sense that the theoretical physicist uses the expression. On the other hand, if one wished to consider as field theories approaches to psychology that come closer to the actual mathematical statement of the interdependencies involved, then the very people who bear the stigma, "mechanistic," would have to qualify as the greatest field theorists of them all. Finally, it must be pointed out that science is concerned with the regularities in the world; that is, with events that repeat themselves. Whole situations do not repeat themselves, at least not very often. Analysis of the elements common to somewhat different situations will be absolutely essential in order to achieve a science of psychology.

This, then, is what the science of psychology, as it begins to be rather definitely defined, is like. It is concerned with the prediction of behavior either in terms of other behavior or else in terms of antecedent stimulus conditions. Its proponents are trying to develop a consistent body of scientific knowledge expressed in terms of whatever lawful relationships may be found to exist among these variables. Because of the tremendous complexity of this task, it has been necessary to use concepts that are considered formally as intervening between stimuli and responses in one case and between predicted responses and predicted-from responses in another. Furthermore, different psychologists develop different kinds of concepts. Some use mechanistic ones, some use field theoretical ones, others think physiologically. Which of these approaches is the best cannot be decided on the basis of *type* of concept. What really counts is the extent to which these concepts aid in the primary task of psychology — the understanding of behavior.

11

An Introduction to Psychological Methodology

T. G. ANDREWS

This selection is the first chapter of a textbook on research methods for students in psychology. It is included here to give the reader a better idea of the stratagems which research psychologists employ in their work to ensure the credibility of results. Andrews, the psychologist, like Benjamin, the philosopher (see selection 3), believes that science begins with philosophical considerations. He develops his theme from the intellectual enterprise to the laboratory procedures.

Dr. Andrews has been a member of the faculty at the University of Maryland since 1949 and is now professor and chairman of the psychology department. He formerly taught at Columbia and at Chicago universities. The article is reprinted with permission, from T. G. Andrews, *Methods in Psychology*, 1948, John Wiley & Sons, Inc.

As the student surveys the literature of modern psychology, he is impressed with its wide scope and the extremely varied methods that are employed in its heterogeneous domain. The data that fall within the boundaries of psychology include such diverse subjects as loudness discrimination in dogs, factors of delinquency in urban areas, spinal reflexes, and psychotherapy. Yet all these are psychology. Not only do the data and sources of data show great diversity, but it naturally follows that the methods of the field must also exhibit some similar degree of diversity.

Within the gigantic framework of psychological science there is some system and order among the facts and among the methods. The purpose of this introductory chapter is to search into the bases of methodology and attempt to bring together some of the common features and differentiating features of the sundry methods that are being employed in the advancement of psychological knowledge. The remaining chapters of the book are devoted to the more specific methods and the technical details of their application in the different fields of interest.

The science of psychology faces several rather fundamental difficulties. One of these major difficulties can be appreciated by a comparison with the so-called natural sciences, in which the beginning points — the raw material — are not under great controversy. Man does not ordinarily question the basic subject matter of physics or of chemistry; such raw stuff constitutes the main stimulus objects of his physical environment. On the other hand, historically, psychology has had some difficulty in trying to decide the boundaries of its subject matter, which has ranged from consciousness to the more modern and operationally definable discriminatory response (*3*). There are many ways of going about the analysis of the behavior which we call the subject matter. As Professor E. G. Boring has indicated, psychology has settled down to the attempt to account man's functional capacities and describe them (*4*).

During its historical difficulties concerning subject matter psychology has fostered the growth of several rather divergent points of view, out of which there have arisen several interesting controversies (*11, 12*). Certain psychologists have also felt compelled to expend considerable energy in trying to combat the easily made claim that their field should not be classified as a science. Perhaps the older subjects of analysis, such as consciousness, did not appear very scientific, but such a controversy is nevertheless a barren one. In this regard it is best to follow the rule, as stated by Karl Pearson (*19*), that any field is a science so long as it consistently employs scientific methods.

BACKGROUNDS OF SCIENTIFIC METHOD

Rationalism and Empiricism

If method is to be the major criterion of science, we can easily see the necessity for becoming conversant with the backgrounds and characteristics of scientific method.

The philosophical techniques used to evaluate and investigate behavior and all other things are rational in nature. Rationalism is the more speculative philosophy which attempts to arrive at "truths" by reasoning from a few rather broad assumptions in accordance with some principles of correct procedure, rather than by turning directly to experience. It is evident that rationalism presupposes a very strong faith in man's power to reason.

There have been some quite satisfactory procedures and criteria for deduction from propositions (*6*), but a major criticism of the familiar syllogistic form is that it has never proved of value in obtaining really new information. Demonstrating by syllogistic reasoning such things as "Socrates is mortal" has not been sufficient to satisfy the more spirited and empirical truth seekers (*16*). Also, the major premise (the large *if*) in such syllogisms is usually an untestable hypothesis. Waiting until the last man has died in order to demonstrate that all men are mortal would not be a fruitful procedure.

Some investigators of a less speculative frame of mind were seeking new information, and so they scrapped most of the techniques of the rationalists and turned directly to nature and experience for the answers to their questions. These questions took on new forms; they were stated with greater precision and were more closely directed to the world of experience. Rather than remaining satisfied with a statement merely because the rules of logical deduction had been followed in deriving it, these investigators tested the statement by determining whether it concurred with other types of observation.

These newer techniques were carried out in an entirely different spirit. Instead of the syllogistic form, the reverse was applied — that of starting from particulars and going toward generalities. This principle of *induction*, however, did not allow the application of convenient criteria of "truth" that had been developed for a syllogistic deduction. Although a little more troublesome, this lack of complete criteria served a purpose, because it helped science to throw off the cloak of absolutism and become progressive by never feeling too certain about its results (*15*).

There were many verbal battles and some actual bloodshed before the more inductive and empirical techniques were fully launched on their way toward the development of the body scientific. In the division of the two camps, the more rugged and individualistic empiricists tended toward over-compensation by throwing completely overboard any connections with the despised speculative systems. During more recent years, however, there has been an interesting and profitable reversion to the extent that scientists are becoming more and more concerned about the philosophical bases of their methods and modes of discourse. Philosophy, therefore, is still with us in all our scientific endeavors (*5, 17, 20*).

For purposes of the description and prediction of natural phenomena, the empirical and inductive methods of science have survived as the fittest. Nevertheless, whenever the scientist poses an hypothesis for investigation, designs an experiment, arranges precision instruments for purposes of recording, statistically analyzes the quantitative results of the investigation, and makes inferences about behavior on the basis of the experimental results, he is making a large number of critical assumptions that are based on some one or another philosophical presupposition. In the following analysis of psychological methodology we shall see how the more abstract tools of science are inextricably mixed with philosophy.

The General Plan of Scientific Method

The scientist selects a tentative explanation as the beginning step in his inquiry, and this tentative suggestion is taken as an *hypothesis*, which directs the search for corroborative or negating facts. The hypothesis is merely a question and is usually quite narrow in scope. These hypotheses are piecemeal but not haphazardly so; each is a question recognized as belonging to a larger family of questions.

An investigation is designed in such a way that it involves a direct analysis of all the major conditions of the hypothesis. Preferably the investigation takes the form of an *experiment*, which is carried out under rigidly controlled conditions during the systematic variation of one of these conditions in particular. These characteristics allow the *reproducibility* of the conditions under which a given experiment is performed. When experimentation is impossible, however, the investigator may employ other methods. Psychological science is founded upon but not limited by the experimental method.

If the results of the investigation are not controversial, the hypothesis may be confirmed (although not proved), and the next step involves tying together the results of a large number of scientifically tested propositions which have some system of relationship. The results of this last step may involve the formation of a *scientific law*, which is only a type of mental shorthand by which a number of facts or relations are subsumed under one simplified statement. A natural law, then, is merely a résumé of a longer and more detailed description.

Another stage, although not an absolutely necessary one, is the organization of a theory to account for the laws. The laws, as well as the theories, represent generalizations from which formal deductions can be made. These deductions are then set up as hypotheses for further scientific investigation. A particular law or theory is thus tested objectively according to whether or not the things which it predicts (which may be deduced from it) are supported or discredited empirically. As more and more correct predictions are added for a particular theory or law, we say that *truth is approached* (not *attained*) by the theory or law.

The process of induction from empirical evidence always involves a treacherous step because the evidence is never complete. In testing a certain hypothesis about human behavior, we can never study all humans but must obtain what is believed to be a "representative" sample from the hypothetical population of *all* humans. Generalizations are thus of necessity made on the basis of partial evidence, and so they are made only as *probable inferences*. The degree of probability — or confidence — that can be attached to scientific inferences differs from one to another, and to this extent the business of science is directed toward diminishing error in the general process of scientific problem solving.

The scientific method becomes more than a mere circular game played by scientists when prediction directs investigation to seek something that has not been previously suspected. Furthermore, some of the most spectacular achievements of science have been produced by the rather straightforward system of inducing a generalization and then deducing from the generalization. Good experimentation, then, is not a hit-or-miss affair or purely random trial and error, and this fact led Darwin to the pregnant statement, "How odd it is that anyone should not see that all observation must be for or against some view, if it is to be of any service."

Theory and experiment are the helpmates of scientific pursuit, theory suggesting the pattern of the maze, and experiment determining the blind alleys and the short cuts. Whenever such a maze is found to be composed only of blind alleys, it is modified or discarded, or at least it should be. To this extent the term *science* should be reserved to describe a body of *verified knowledge*, and the most satisfactory criterion of science is in terms of the method of verification. Knowledge of facts without knowledge of the procedures to discover the facts does not constitute science, and this is especially true in psychology. Knowing about the behavior of people does not qualify one as a psychologist.

Classification of Psychological Methods

When we try to catalog the many methods of investigation in psychology, we find that there are several types of general methods and several types of more specific techniques. The various fields of psychological study have their own specific techniques of research. The more general methods, however, are not peculiar to the separate fields but are used as common property by all psychologists. These general methods of investigation may be broadly classified in several different ways; one classification scheme is as follows:

1. Methods of selecting the individuals to be studied.
2. Methods of controlling extraneous stimulation during the investigation.
3. Methods of instructing or directing the attention of the individuals under investigation.
4. Methods of presenting the stimuli.
5. Methods of registering intermediate bodily changes.
6. Methods of observing and recording overt responses to stimulation.
7. Methods of analyzing and synthesizing the data resulting from an investigation.

Although there is some overlapping among these classes of methods, each class pertains to humans or lower animals, to learning, sensory, motivational, motor, social, abnormal, child, personality, educational, or industrial investigations. This classification of methods is easily seen as depending to a considerable extent on the *stages of the investigation.*

Another and somewhat old-fashioned type of classification is based on a differentiation between subjective and objective methods. Because of the nature of many psychological phenomena there has always been some concern about this differentiation. Insofar as the direct experience of an individual is to some extent a private and subjective phenomenon, many of the methods used to study direct experience and mental processes are called subjective. The general technique for investigating these phenomena — thought, images, feelings, sensations, perceptions — has been to ask the subject to report on these experiences, to introspect. This general type of observation has been distinguished from objective observation, which is not so dependent on the biases or judgments of the individual observer and better permits independent verification. Such a methodological distinction has become of less importance with the growing realization that all the subjective methods can be handled with a considerable degree of objectivity and that all the objective methods have some of the characteristics of subjectivity.

Still another and somewhat more fruitful classification of psychological methods is in terms of the conditions of control and the purposes of the observations. The general methods may be characterized as *experimental, differential,* or *clinical.* These classes overlap only slightly, and a choice between them is usually made on the basis of the specific problem to be solved and the nature of the assumptions that are possible or advisable for a particular investigation.[1]

EXPERIMENTAL METHODS

Experimentation holds the central position in psychological science, as it does in all other sciences, for the reason that it best exemplifies the principles of scientific method (20, 22). The experiment consists of objective observations of actions performed under rigidly controlled conditions. The hypothesis for investigation is chosen and is stated in such a manner that it can be tested rather completely. One factor, the "causal" one, is usually varied through a predetermined range of values. In the more classical scheme, changes are produced in one variable at a time, and the effects of these changes are observed and measured or recorded while all other important variables of influence are held constant in their effects (2, 7).

The Independent and the Dependent Variable

One manner of illustrating a typical design for a psychological experiment is shown in Fig. I. This diagram indicates that a certain type of specified action, the *dependent variable,* is observed while it is influenced by arbitrarily produced changes in some specified stimulating condition, *the independent variable.* Other stimulating conditions that might influence the dependent variable are not allowed to vary during the course of the experiment; i.e., their influences are held constant. On the other hand, actions other than those of one particular dependent variable are quite naturally being carried on by the organism, and these are indicated by the lines R_1 and R_3. In some experiments measures of these other responses are recorded during the whole process, and under such conditions more than one dependent variable exists in the experiment. Such is the case in an experiment which is designed to

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[1] All three general methods may be used in any one psychological research project. For an example of the joint use of these methods in one series of interesting studies the reader is referred to (18).

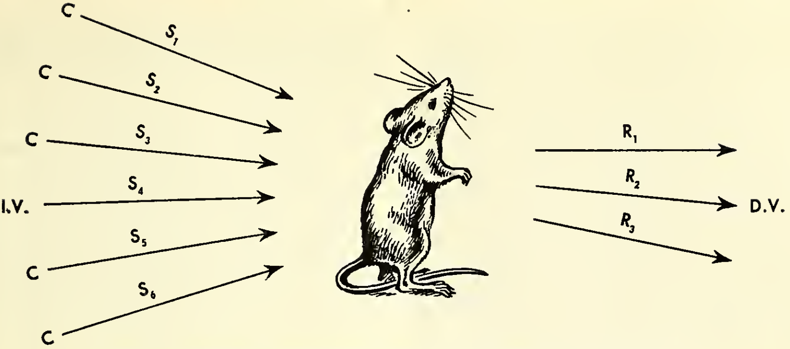

Fig. 1. A diagram to represent the scheme of a psychological experiment.

determine the effects on both mood and efficiency (two dependent variables) of changes in oxygen content of the air breathed by the subjects in the experiment.

Thus there is only one independent variable in an experiment of the classical design, and so we often hear of the *law of the independent variable.* This law states that we are to keep all causal factors constant except one, which is to be systematically varied while observations of concomitant or successive changes in the dependent variables are made. Such a procedure rules out all other possibilities of producing in the results effects not attributable to the one independent variable. Certain systematic experimental designs are now available that enable the experimenter to employ more than one independent variable in a single experiment. A discussion of this important point will arise later.

The foregoing description is not to be taken as indicating that all the factors involved in any experiment are under the investigator's control. If the observations could be completely controlled, the experimenter would need to make only as many observations as there are degrees of change in the independent variable. This may be the situation in certain physical sciences, but certainly not in the behavioral sciences, where the behavior of the organism is quite variable and is influenced by a multitude of factors, both internal and external. Because of the relatively great variability of behavior, it is necessary for the experimenter to obtain several observations under each condition of the experiment. An average tendency among the observations for each level of the independent variable is then computed, and that average tendency is accepted as a more dependable and representative value for the dependent variable.

Importance of Controls

Many of the factors that would influence and modify the behavior specified by a particular dependent variable must have their influence removed from the experimental situation. Insuring adequate controls is one of the most important problems for the experimentalist to face. The influences of uncontrolled factors may obscure the results of experiments that would otherwise be critical, and yet psychology cannot exert control over all the possible sources of influence that are extraneous to the independent variable. The result of this seeming impasse is that all experiments must be repeated (replicated) and must produce consistency of results under a variety of conditions before they become accepted as demonstrating "facts." The scientist must always be prepared to scrap his results whenever they are demonstrated to be untenable in the light of replication under more precise control.

Functional and Factorial Experiments

As a result of having carried out an experiment, the psychological investigator usually wishes to express a relationship between the independent and a dependent variable. Seeking for such *concomitant variations* is one of the most important endeavors in scientific work (6, 23). As a result of this type of information science is able to understand causal factors and make predictions.

Through experimentation we wish ultimately to establish statements of scientific law, or at least generalizations which approach the status of laws. The laws, our goal, express relations and thus become the model for an important type of experiment. When the researcher wishes to determine the functional relationship between two experimental variables, he first establishes the range of the independent variable within which he will experiment. As a next step he chooses several values within that range and stimulates his subjects with each of these values (or under the conditions of each of these values) while he observes and records the resulting changes in behavior of a specified sort (the dependent variable). This general procedure identifies the experiment as being of the *functional type,* i.e., one in which a functional relationship is sought.

Quite often, however, the researcher must cast about in a more exploratory fashion to determine factors that will offer some chance of showing important and useful relationships. Instead of using several values along the independent variable, the experimenter may use only two, as in the typical experiment wherein a difference is sought between the presence and the absence of a certain feature. The results of such experiments as this do not indicate the functional relations between variables but do show whether the factor which has been changed produces any measurable change in the dependent variable. We may classify experiments of this second type as *factorial.*[2] Experiments of the factorial type are most useful as preliminary stages in an experimental program; they are used mainly to answer the question *what,* whereas experiments of the functional type are designed to answer the question *how.*

The Control-Test Method

In order further to see how experiments are designed to answer psychological hypotheses, we may make another type of classification of experimental methods.[3] One of these classes may be called the control-test method, which consists in the observation of performance under what may be called normal conditions and then again with one condition changed. The control-test method is an example of the factorial type of experiment at its simplest level. For example, visual acuity might be measured under ordinary conditions of illumination and then under the condition of glare. Actually the measure would be taken several times under each condition, but it would not be necessary to have two different groups of subjects for the experiment. The control-test method is sometimes called the *method of difference.*

The control-test method is used when there is little or no practice effect or transfer from one condition of measurement to the other. Visual acuity is not changed by its measurement, although the process of measurement is usually novel or complex to the degree that it may take the subjects a few practice trials to learn to follow the instructions and to give reliable reports. Such practice trials, of course, are not recorded.

The Control-Group Method

This technique consists in observing two equated groups of subjects who are performing under the same conditions except for the influence of one element. The scale of presence-absence of this one particular element represents the independent variable of the experiment and identifies it as factorial in type. The difference in performance between the two groups is the dependent variable and is a function of the independent variable if all other sources of influence are eliminated.

In this experimental design it is very important that the two groups involved have equal potentialities to begin with. In order to approximate this condition the groups are equated; i.e., they are so chosen as to be at the same level of measured capacity on the variables that may conceivably affect the results, and ideally they should be equated for *all* characteristics which might bear on the investigation at hand. Because perfectly equated groups are a frank impossibility, the investigator is usually content to equate for those characteristics which seem most likely to influence the dependent variable.

An example of the control-group technique may be described in the following manner. The general hypothesis may be that practice in memorizing increases memory ability. Such an hypothesis defies direct experimental test, and so a more particular aspect of the general statement is chosen: practice in memorizing certain prose increases ability to memorize certain poetry. In designing an experiment for an adequate test of this hypothesis, the first step is to select a group of subjects who are reasonably homogeneous in memorizing ability and do not differ from one another very much in intelligence. All the subjects are then given a test (the *fore-test*) to determine their ability to memorize poetry. On the basis of the scores from this fore-test, the subjects are divided into two groups such that the average poetry-memorizing abilities (as measured by the test) are the same. It is also desirable that the variabilities of the two groups be equal. One of the two groups is now chosen as the experimental group, and a period of practice in memorizing prose is spent by this group. The other group becomes the *control group* and does not receive any of the practice on prose. Both groups are then given a final test on memorizing poetry.

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[2] The term factorial, as used here, is not to be confused with factorial analysis or with factorial design, a term used in certain kinds of statistical analysis.

[3] This classification and analysis of psychological experiments has been suggested by T. A. Jackson (*14*).

The accompanying hypothetical data may be used to indicate the expression and treatment of experimental results that might accrue from this investigation:

	Fore-Test (poetry)	*Training Period* (prose)	*Final Test* (poetry)
Experimental group	62	———	79
Control group	62	……	66
		Difference =	13

The two groups were equated at 62 (same measure of proficiency) on the fore-test, and the experimental group was 13 points better than the control group on the final test. This difference is now attributable to the effects of the training period on the experimental group, because the two groups were the same in most other important respects. It is to be noted that the control group in this hypothetical experiment became slightly better (by 4 points) at poetry on the final test, presumably due to the practice administered in the very taking of the fore-test. Therefore, we may assume that the experimental group likewise gained 4 of their 17 points as a result of the practice afforded by the fore-test.

The control-group method is used whenever it is possible that the function to be measured (memory in the experiment described) may change every time it is measured. That is, there may be and usually is some practice effect within the fore-test itself, and the only way to determine the amount of this unwanted practice effect is by the use of the control group.

The Matched-Pair Technique

The theory of the control-group method is applied to situations other than those involving growth or learning. When choosing two groups for the purpose of evaluating the effects of an independent variable, the investigator often selects the subjects in pairs, and this procedure is known as the matched-pair technique. In such cases the independent variable may form the basis of the selection. For example, an investigator may wish to determine whether bright children are more or less suggestible than dull children. This hypothesis is an interesting one and has been tested in a rather precise manner by Simmons (*21*). Knowing that suggestibility may be influenced to a considerable extent by age and sex, Simmons chose children in pairs in such a way that the two members of each pair were exactly equal in age and were of the same sex. One member of each pair was dull, with an intelligence quotient below 90, and the other member was bright, with an intelligence quotient above 125. For our purposes we need not be concerned with the way in which suggestibility was measured. It will suffice to say that the groups were treated in exactly the same manner in the investigation and a numerical suggestibility score was obtained on each subject. Interestingly enough, the bright children averaged 30.7, and the dull children averaged 46.3, the latter being definitely the more suggestible. In this factorial type of study by Simmons the independent variable was intelligence, which she "varied" in the manner in which she selected her groups.

It is worth pausing for a moment to note that Simmons' investigation does not qualify as a real experiment, which necessarily involves the more purposive manipulation of the independent variable. It is, however, sometimes desirable to turn to nature and find conditions that conform rather closely to what is wanted and so to utilize these conditions without further manipulation. In such cases selection may replace control. After all, intelligence is not a variable which we can easily manipulate and vary, and therefore we must turn to individual differences for a scale, rather than to a physical scale which can be employed in the laboratory.

The Practice Method

This method consists in training the subject or subjects in the function to be used until no more improvement is made as a result of training or practice. After such a level of practice is reached, variations in performance may safely be ascribed to variations in the conditions under which they are made. When a subject is used as his own control in this manner, it is obviously necessary to reach a high practice level before beginning the experiment proper. The practice method is not frequently used in experimentation because a great deal of time is required for each subject, thus making it difficult to obtain a very large number of subjects; also the method is obviously not suitable for studies that pertain to the early stages of the learning process. These factors that weigh against the general use of the practice method clearly indicate a central problem in experimenting on organisms; i.e., the organism is subject to change by the very measurement process itself — a feature especially peculiar to psychological experimentation.

The Rotation Method

The rotation method consists in presenting two or more stimulation situations to the experimental subjects in as many sequences as necessary to control the serial effects of fatigue or practice. For example, if we wished to determine the relative influence of two specified conditions, A and B, on a group of subjects, we would *not* measure all the subjects under condition A and then under condition B. Condition A might so fatigue or train the subjects that the measures under condition B would not be independent of the fatigue or training effects — another case in which the measuring process changes the behavior. We would thus be faced with two alternatives. We might obtain half the measures for condition A, all the measures for condition B, and then the other half of the measures for condition A. This technique is sometimes called the ABBA order or *counter-balancing.* Another alternative is to separate the subjects into two equated groups, one of which receives treatment A and then B, whereas the other group receives treatment B and then A. Both sets of A results and both sets of B results may then be combined and the difference between them calculated.

The purpose of the rotation method in experimental design is fairly obvious. The advantage or disadvantage of placing one condition first in the sequence is balanced for the two conditions. An assumption is made in this logic, however, to the effect that the transfer effect from condition A to condition B is the same as from B to A. This assumption may or may not be sound, and it is probably made more often than is justified. At any rate, the rotation method should be applied only with some caution, and it is usually a compromise method. Ideally, large groups of carefully equated subjects should be used in an experiment, one for one condition and the other for the other condition. The rotation method, however, is usually resorted to when only a limited number of subjects are available, and with this method all the subjects are measured under all conditions; the two groups are equated because they are the same persons. This assumption, however, may be a delusion because a subject is not the same after he has had a certain test — he may learn important elements or attitudes for the next test.

Let us briefly go through a typical situation in which the rotation method is employed as a group demonstration for classes in experimental psychology. Using the hypothesis that the three typical methods of measuring retention of verbal material give different results, we choose three lists of nonsense syllables in such a way that the three lists are of equal difficulty. (This equality can be obtained from lists published for the purpose.) Calling these lists A, B, and C, we have a large group of subjects memorize the lists in the order ABC and under standardized conditions. For each subject we obtain a score on each of the three lists, and three scores are then averages for each person. We send the subjects away with the admonition that they should not rehearse the material in any way and that they should return to the laboratory at a designated time in the future.

From the set of scores we equate three groups of subjects, I, II, and III, such that they are equal in their demonstrated ability to memorize the material. When the subjects return for further observations, we instruct them in such a way that the different groups take the retention measures in the following manner:

Group I

Recall test on list A
Relearning on list B
Recognition test on list C

Group II

Recognition test on list A
Recall test on list B
Relearning on list C

Group III

Relearning on list A
Recognition test on list B
Recall test on list C

Note that all three measures of retention occur in all three orders. Thus no method of measurement gets more practice or fatigue effect than any other when we combine the data for analysis. We pool the data simply by taking all the scores on *recall* together, those on *recognition* together, and those on *relearning* together. Remember that the lists were equated before the investigation began.

As a general result, in analyzing the data from such an experiment, we would probably find that methods of measuring retention differed and that recognition produced highest scores, relearning next highest, and recall lowest. In such an experiment the lists might be made up of different types of materials: one list of related words, another of unrelated words, and the third of nonsense syllables. Our retention tests would probably then indicate that the list of related words is retained best and the nonsense syllables least. An additional question of interest would then be whether there was considerable interaction between one of the lists and one of the measures of retention. For example, we might find that recalling the related words was relatively a very easy task, although recall in general did not produce high scores. This problem of interaction can be approached with proper experimental designs and is becoming an important aspect of experimentation in psychology (9).

If the lists of nonsense syllables were not equated in this experiment or if the lists were made up of different materials, a more complicated experimental design would be needed, and we would probably have our groups of subjects do different things. A characteristic to note in such a case as this is the possibility of interaction between a certain type of material and a certain method of measuring retention.

Notice that in the foregoing experiment two independent variables were involved and were active in conjunction with one another. This appears to contradict the statement made earlier to the effect that we employ only one independent variable at a time in an experiment. There are, however, some new types of experimental designs based on concepts that differ rather radically from the classical ones as to the number of inquiries that should be included in a single experiment. In the newer experimental designs all the factors to be tested are varied concurrently in all possible combinations. Such complicated experimental designs are really extensions of the rotation method and are based on a statistical method called analysis of variance (9, 13). These techniques allow much greater efficiency than the classical technique of the single independent variable.

Artificial Characteristic of Experiments

A meaningless criticism has frequently been directed against experimental methods as used in psychology. This criticism is to the effect that real human behavior, the kind of everyday behavior that we wish to understand, occurs outside of laboratories, and when it is studied in the laboratory under the usual conditions of rigid control and precise measurement, it is not the same behavior. This statement is of course quite true, but the experimentalist does not take it as a serious criticism because he actively seeks for stringent and artificial conditions, rather than attempting to avoid them and study "daily life" behavior as it occurs.

Because of the extreme variety and complexity of behavior and of the forces which influence it, no one would be able to establish a science of behavior by trying to study it under "normal" conditions. Whenever we begin a behavioral investigation, normal conditions do not exist because the measurement situation (even the interview situation) is not "normal." As stated near the beginning of this chapter, scientific hypotheses are necessarily quite limited in scope. It is only by the piecemeal selection of a few very limited aspects of behavior at a time and by carefully planned and intensive analysis of those limited aspects that successive investigations may allow us to construct a picture of behavior such that we may understand it, describe it, predict it, and control it. In all this work there is an obvious *error of fractionation*, but the error is important only when laboratory conditions are incorrectly thought of as counterparts of daily life activities.

Woodworth (*24*) has stated an analogous situation in the history of physics (the experimental techniques of which science are more easily "acceptable" to the layman). In order to test the law of falling bodies with adequate precision and control, objects of different mass are dropped simultaneously in a vacuum. The counterpart of this situation would be very unusual if it occurred in nature: what is more "unnatural" than a vacuum?

There are, of course, psychological methods of investigation which are not so rigorous nor quite so artificial as experimentation. The psychological investigator therefore must be acquainted with the other techniques that may be applied to problems that temporarily defy laboratory experimentation. The second major class of psychological methods of investigation is called *differential*, and these methods will be seen to meet more nearly some of the objections leveled at the experimental methods.

DIFFERENTIAL METHODS

Non-experimental Variables

The class of methods called differential includes those systems of techniques which employ *individual differences* as variables of investigation. An example of such use has already been described in the investigation of Simmons. In such studies there usually is no purposive *manipulation* of the independent variable; the investigator merely chooses his subjects according to certain criteria, and the measurements on the subjects themselves form the variable or variables for the investigation. The criterion of selection of the subjects may become the independent variable for an investigation (intelligence, in Simmons' study), but it is to be noted that this variable is not under the full control of the investigator, to be varied up and down a given scale at will and with full freedom.

At first view the above differentiation between experiments and differential methods may appear quite artificial, and it is true that all psychologists will not agree to such an apparently artificial classification scheme. Nevertheless, it should always be made clear that the independent variables resulting from individual differences are never under the investigator's control to the same degree that experimental variables are. Also the scales are different in kind.

Although the experimental methods are more precise and the inferences made from the results of these methods have greater likelihood of validity and can be more easily verified, it cannot be said that they are always more desirable than the differential methods. Experimental methods establish the model of objectivity for the other methods of psychological investigations, but experiments obviously cannot be devised for all the problems that are raised in the heterogeneous subject matter of psychology, as will be seen in a perusal of the various techniques described later in this [Andrews'] book.

Correlational Methods

It is easily seen that most correlation studies in psychology fall into the class of differential methods. The major studies of intelligence and aptitudes and personality and a large number of those on social behavior are therefore classed as differential investigations. In these studies the psychologist takes people as they are and studies what they do, usually without changing the conditions under which they respond to the "tests" or perform the desired tasks. (If the conditions are changed, the situation becomes more like an experiment.) The subjects will naturally differ from one another in their behavior, and the investigator is usually seeking *concomitant variations* in other ways in which they behave.

The importance of this general technique for purposes of prediction can easily be seen from a few simple examples. It is quite important to be able to predict what kind of work each person can do best in order to produce the most efficient matching of workers with jobs. Attempts at solution of this problem are handled mainly by correlational techniques, in which workers are rated in terms of success on the job, and these ratings are correlated with a number of test scores on the same workers. Those tests that produce the highest correlations with the ratings of merit are then employed in the screening of others for the job in question. Other persons may now be given the same tests, and those who score highest on them will be judged as having a higher likelihood of performing efficiently on the specified job.

The foregoing is an example of the use of correlation procedures in analyzing related scores, and the literature of psychology contains thousands of published studies on these problems. Another general type of application of the correlation method is directed toward the nature-nurture problem in psychology, and involves studying pairs of persons who are genetically related. The score of one member of a pair is plotted against the score of the other member, and this is repeated for successive pairs. Most studies of this general sort indicate that in terms of intelligence test scores identical twins correlate quite highly (.90), fraternal twins less (.70), and siblings still less (.50), while relations as remote as grandparent-grandchild correlate hardly at all (.15). Such correlation studies as these on related pairs are really quite inadequate because of the presence of another correlating variable: similarity of environmental conditions during early development. The studies do, however, constitute examples of how correlational analyses are applied for the purpose of testing relations other than between one mental test and another.

The Longitudinal and the Cross-sectional Approaches

The problem of mental growth is a good one to illustrate the differential methods in studying concomitant variations. In investigations on this problem mental progress, as measured by some type of test, is observed and charted. There is no attempt on the part of the investigator to alter the normal course of development because it is the normal trend that is to be discovered. This general technique obviously raises an important issue, in which the investigator must choose whether to retest a group of individuals at successive ages, the *longitudinal approach*, or to test different age groups at the same time, the *cross-sectional* approach. Each of these approaches offers its own peculiar difficulties (*1*, *10*). It is enough for our purposes here merely to indicate the general nature of the differential technique in contrast to the experimental approach. The experimental approach has no way of giving information on the general problem of mental growth, although certain more limited hypotheses concerning such growth may be studied experimentally. The issue in this case is that both age and mental ability go along without our being able to do much direct manipulation of either of them. The investigator merely takes things as they are and determines the relationship between two specified natural phenomena. In order to study the differences between males and females in terms of certain psychological or physical traits, differential methods must also be applied. We most certainly cannot experimentally vary the sex of the human subject.

The cross-sectional approach has become an extremely important technique in an active democratic society. By its use determinations may be made of such phenomena as the morale effects of certain government policies, of electioneering effects, of food habits during critical shortages.

General Statistical Methods

The differential methods have often been called statistical for the reason that statistical techniques become the major devices for studying individual differences. This fact can be seen from a brief listing of the more important characteristics of statistical methods: (a) efficiently describing masses of data in terms of relatively few numerical expressions, (b) expressing the relationships between variables, (c) allowing the extensions of scientific inferences to be tested under conditions of mathematical exactness.

The commonly noted relation between differential methods and statistical techniques does not mean that statistics are not considered important tools to be applied in experimental methods. The data that result from experiments are expressed in mathematical form, and statistical analyses are applied to these data in order to exhaust all the useful information from them. It is also through statistical methods that the most efficient experimental designs have been derived (8).

CLINICAL METHODS

The clinical methods have a different frame of reference from the experimental and differential methods in psychology. The word clinic originally referred to "something pertaining to a bed," and it has been extended to mean "directed toward the individual." Whereas the experimental and differential methods have been established to ascertain facts which transcend the individual case, the clinical methods are directed less toward investigations of general behavioral facts and more toward individual appraisal and adjustment.

SUMMARY

In this introduction we indicated some of the causes in the development of the scientific method and also some of the characteristic features of scientific method in the steps intervening between investigation and theory. A rather crude classification of psychological methods was made, and the more important features of each of the three types were described. In experimental methods the characteristic features of the independent and dependent variables were discussed, and the difference between "factorial" and "functional" experimentation was evaluated. Some of the basic forms of psychological experiments were analyzed as (1) the control-test method, (2) the control-group method, (3) the matched-pair method, (4) the practice method, and (5) the rotation method.

Differential methods were characterized by their dependence on individual differences for the variables under investigation, and clinical methods by their individual-centered interests. Some of the inter-relationships between the different classes of methods were shown, and it is hoped that the student will become more and more aware of this characteristic of interdependence among the psychological methods.

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12

Summary

WILLARD L. VALENTINE

The final selection in this part is a delightfully written summary of a book of readings which appeared in 1941. That book was devoted to the demonstration of how fruitful is the experimental method in behavior science. Although many new and ingenious experiments have been made since then, his summary is still an interesting and correct account of the three sources of behavior determination — structure of the body, environment of the person, and one's behavioral history. Professor Valentine introduces his summary by reviewing some of the difficulties of applying scientific methods to the study of behavior, and concludes with a consideration of the largest concept in the psychologist's thinking — personality.

The late Professor Valentine was for many years chairman of the department of psychology at Northwestern University, and he held important positions in the American Psychological Association. The selection is taken from his *Experimental Foundations of General Psychology*, rev. ed., Farrar & Rinehart, 1941 (pp. 414–446), by permission of the publishers.

Psychology is an attempt to understand why people behave as they do; but psychology is not the only subject-matter field concerned with understanding human beings. Novelists, philosophers, poets, biographers, among others, are engaged in the same activity. There is, however, a fundamental difference in the method of attack on the problem which characterizes psychology and sets it apart from all these literary activities. The method did not grow up overnight. Historically there have been many different systems of psychology and the future holds out promise for even more to come. Suffice it to say that first attempts were highly speculative and terribly abstract. They were literary and philosophical. Then, near the close of the last century, came the modern note. The notion developed that it would be wise to take over into psychology the scientific method that had proved to be so valuable in understanding the nature of the physical world. This procedure, it was thought, would enable psychologists to check up on *speculations* regarding the nature of man by actually studying men in the laboratory, just as the botanist studied plants and the geologist studied rocks. It was proposed to apply the same scientific instruments that other scientists used and to invent new ones that would enable the psychologist to penetrate beneath the obvious and superficial surface of psychological happenings. And herein lies a long story of psychological instrumentation which is interesting in its own right, but again can not be elaborated.

There is one fundamental difficulty hampering a complete application of scientific method to psychological events. It lies in the fact that it is easy enough to be objective and scientific with regard to mountains, rivers, canyons, trees or shrubs, or even other animals, but it is hard to be objective and analytical about other human beings, let alone oneself. We are reared to respond sentimentally and personally to members of our own families; this training carries over into other person-to-person relations and is cultivated by certain of our institutions, so that a very special training is required if one is to adopt a different attitude as an adult. If this book has helped anyone to cultivate an objective, detached, analytical attitude, one of its purposes has been fulfilled.

Some people object to the scientific point of view in dealing with other people because they think it cold, austere, harsh, hard, or severe. But it is not that, or at least it need not be. To be objective about other people means that one can better understand one's own mother, father, brothers, and sisters. When you understand why somebody else is the person that he is, you can evaluate and appreciate his performances and his failures with a sympathy and a warm understanding that you are not capable of as long as you believe him to be capricious, perverse, erratic, inexplicable. Unpleasant people are not unpleasant because they choose to be or because they were born under unfortunate planetary influences, but because the circumstances of their lives make them that way. The framework for understanding these things, offered in this book, consists in regarding human nature as the product of three factors — a person's structure, his immediate surroundings, and his past history. Since there is no method at present of actually quantifying these factors, there are various opinions concerning the weight they should have in explaining human behavior. Geneticists and biologists generally are prone to emphasize the inherited factors (structure); physiologists emphasize the momentary stimulus conditions, both external and internal; while psychologists, modern sociologists, and educators attribute greater efficacy to the biographical factors.

This whole volume was designed to show how the scientific method can be used to determine the relative importance of these factors in a general way. Although the formula for the scientific method — observing, classifying, hypothesizing, and testing the hypothesis — is very simple, the practical application of this formula to the problems of psychology is not. We have not thought about behavior in terms of the scientific interpretation long enough for the method to become second nature to us. Statements that ought really to be hypotheses are announced as dogmatic assertions. The scientific point of view is always the unassertive, undogmatic, tentative position which does not appeal to large numbers of people who want final answers.

Another difficulty has always been the fact that many speculations about human beings are framed in such a way as not to be susceptible to test. Every day we make observations on what we call another's "intelligence," his "will power," his "aptitudes," his "emotions." When we do this we imply or posit relationships between these abstractions and others equally remote from performance without considering the likelihood that we are talking meaningless twaddle.

STRUCTURE

The structure of a person's body is important in the determination of the behavior he exhibits. By "structure" we mean the microscopic anatomical details as well as the grosser features of physique that are open to the inspection of all. In saying this we are not implying that structure is the only or even the most important determinant of human destiny. Just how important it is depends upon what particular aspect of behavior is under consideration and what item of structure is held to be responsible.

Unimportant Structures

We certainly know that the color of a person's hair or skin is related in no precise way to any of his psychological properties. The shape of his hands, the contour of his nose, and the size of his ears are all equally unimportant. Because these things are obvious, in many superficial analyses they were, and still are, held to be the causes of, or to be related to, capacities, talents, temperament, and general capability. We have shown that the important principle of control reveals that all such assertions are utter nonsense.

When we enter the field of psychological differences between the various races of man, we get into a more controversial field — controversial largely because we have inadequate data with which to work. The evidence that is available indicates that here again those who attribute psychological differences to differences in the shape and size of eyes, head, lips, hair, color of skin, and bodily proportions are being blinded to other circumstances by these obvious and superficial differences between the various races. The point of view expressed and implied here stands for a skeptical attitude toward anybody who insists that a white man is superior because he is a Caucasian, or a Negro is inferior because he stems from African forebears.

It has also been held that special talents are determined by structure — one frequently hears that "teachers are born, not made," or "he wasn't cut out to be a physician," "he is a born artist" — the implication being that there is some structural determinant for special aptitudes. No basis of fact supports these assertions. They are made by people who have failed to observe that motivational effects could account for talents of special kinds.

Important Structures

Undoubtedly some fraction of the feeble-minded are inadequate because they lack certain anatomical details in the nervous or glandular system. Just what is lacking we are unable to state with any certainty. Here again, a healthy and vigorous skepticism should greet those who proclaim that all feeble-mindedness is the result of structural deficiencies in the nervous system, or that the onset of senile dementia is determined by the slowing up of metabolic processes in the brain, or that involutional melancholia is caused by the cessation of menstruation alone. These are again only the outward, obvious differences. Controlled observations would undoubtedly uncover more important causal factors. One very important way in which structures are indirectly the causes of behavior lies in the manner in which other people react to our structural characteristics. If a girl is unusually tall, unusually thin, or greatly overweight, her treatment by her associates of both sexes differs from what it would be if she more nearly resembled the popular conception of a girl's physique. In the case of children, particularly, any distinguishing feature of structure or coloring is commented upon and evokes a variety of reactions in other people. The treatment thus accorded different children is varied enough to account for major differences in their actions that appear in later life.

There is also some evidence that glandular balance is important in the determination of behavior. One example of this lies in the field of sex, where the differences between masculinity and femininity have been laid at the door of the glands involved. There is evidence, however, that masculine and feminine behavior does not depend completely on glandular structures; effeminate men or masculine women are made more often by the treatment accorded them in childhood than by glandular imbalance. Even when this imbalance is serious enough to prevent the appearance of secondary sex characteristics, the very lack of these properties is noticed and commented upon by a person's associates. As a result it is difficult to know how much of the ensuing behavior is caused by the comparisons that are made with other people and how much is due to the malfunctioning glands themselves. Even a hyperactive thyroid gland, which normally produces an unusual amount of energy, may not be totally responsible for all the tension that is observed in people with overactive thyroids. Again, we respond differently to people who are tense; they make us tense, and we then add to their tension.

Inheritance

Structures are primarily determined by patterns laid down in the very earliest stages of embryological growth. Of course, there has to be an available supply of the materials needed in growth or else stunting or malformation will result. But in the next generation size is restored to normal if adequate materials are available. To think of inheritance without at the same time thinking of an environment capable of supplying essential materials for growth is to become hopelessly muddled in abstractions. Nevertheless, by keeping the environment constant one can, by selective breeding alone, change in a marked degree whatever structural feature he sets out to change. Mice have been made as large as rats, and rats as large as cats. Presumably there are limits — cats have never been made as large as elephants. As far as human endeavor is concerned, the limitations set by biological restrictions are so wide that it is only rarely true that one's accomplishment is truly limited. These experiments with animals have implications for human problems, but one can expect inheritance to solve psychological problems only in so far as structures are important in the determination of psychological events — and, as we have been showing, structures are not so important as the traditional concepts have led us to expect. Inheritance means that one's *structure* is determined by the character of the germ cells of one's parents, and only that — it does not mean that *behavior* is biologically determined by one's ancestors.

Maturation

The rate at which elaboration of bodily structure proceeds as one becomes older is important in determining superiority in childhood. These rates seem to be determined principally by heredity, and without any stimulation from the external environment or in spite of environmental deficiencies. This fact would be extremely important if there were any close relation between early superiority and later accomplishment. This relationship does not seem to be close enough to enable us to venture a prediction of mature capability based on childhood superiority.

Implications

From the evidence presented in previous chapters as well as in this summary, it should be perfectly clear that man is first and last a biological creature, a fact so frequently overlooked in idealized descriptions. Biological factors establish definite limits on human accomplishment.

ENVIRONMENT

The conditions surrounding one at any time in the form of lights, sounds, odors, and so on, do determine behavior. They do not, however, dominate the picture so completely as they were supposed to do by earlier physiologists and psychologists, who believed that a person's actions were principally determined by stimuli coming from the outside.[1] Human behavior was thought of as being generated by externally originated stimuli playing upon a fixed and passive human frame.

Today internal stimuli arising from tissue conditions are recognized as the principal source of a person's behavior. It is characteristic of this class of stimuli that they are insistent[2] and result in heightened tensions in skeletal as well as visceral musculature. They are also the important source of glandular stimulation.

External stimuli serve to guide and to modify processes already under way as a result of internal stimulation. This distinction between external and internal stimuli is an important one.

Some authors have found it convenient to differentiate between physical and social stimuli, principally to make the point that social stimuli result in responses completely out of proportion to their physical energy values. This is only a distinction between sensing and perceiving, and leads us to our final class of behavior causes.

BEHAVIORAL HISTORY

It should be perfectly obvious that a given stimulus can be sensed only in terms of a background of previous experiences in connection with that stimulus object as well as with others. Things are perceived only in settings. Whether a given element or some other one will stand out from a background depends on a person's past experience as well as on the nature of the energy distribution in the whole stimulating situation.

A human infant at first is a strictly biological organism. But from the first day onward his nurses and family use different techniques in handling him so that within even a few days individual babies commence to acquire different habits of sleeping, eating, and elimination. It has been observed that nurses in large hospitals treat infants left in their care in different ways — for instance, if an infant has some attractive characteristic they spend more time with him and give him an extra pat or two — even though they handle hundreds or even thousands of babies in a relatively short time. This extra attention soon causes the favored infant to demand more attention than his neglected brother receives or expects. Once at home, the newest member of a family is accorded the treatment dictated by the domestic, economic, and cultural background of the family group. In the higher socioeconomic levels the father takes a more active part in rearing a child. Lower levels are still dominated by an outmoded concept of "women's work." Mother, father, nurses, brothers, sisters, friends — his social environment — lead to the development of habits that result in characteristic ways of dressing, speaking, gesturing, and of thinking and acting generally.

PERSONALITY

In common parlance all these habits are subsumed in the word "personality." The word has been used to cover such a wide variety of habits, attitudes, and opinions, in psychology as well as outside the discipline, that it has very little scientific value at the present time. If one is addressing a lay group, the word usually connotes an ability to "make friends and influence people" that is unfortunate for a sober consideration of the factors involved in "personality" make-up. To charlatans the word means some sort of mystic power which somehow directs one's actions and guarantees successful living. To the immature, personality means chic in dress and coiffure, and clever repartee. People who are not up to the minute in dress and action are even said to have *no* personality. All these ways of conceiving personality are extremely superficial. On the other hand, to the reflective thinker, personality means individuality in all these things, but more important than these, individuality in the organization of complex habits of thinking and doing, particularly in the field of dealing with other people. The crux of the matter seems to lie in the fact that we have to learn to deal with both the nonpersonal objects (and relations between them) and the people in our environment. Some of us learn to be expert in handling nonpersonal situations; let us say those paint brushes and spatulas that are involved in getting a painting upon canvas. In such a case we may be recognized as talented in art, but at the same time we may have failed so miserably in dealing with people that we have to work in an atelier as far removed from human contact as possible. In this case we would say that our personality development has been unusual, abnormal, esoteric, or eccentric — devoid even of rudimentary mastery of the techniques of person-to-person interrelations. Other and perhaps more common examples of the same principle are found in the "grinds" of the college campus, the technicians and experts of various kinds in business and industry who are endured only because of the value of their specialized skills. I do not mean to imply that all good students and all expert technicians are lacking an ability to deal with people or that adequate personality adjustment is characteristed by a lack of talent in dealing with nonpersonal situations, but in our society there is always the danger that some such condition will develop because we make it possible for these people to make a living. We may even encourage them to be inept in interpersonal relations.

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[1] It is perfectly true that a single cell cannot originate any kind of activity. The instigation for activity of the cells that compose our bodies must come from the outside of that cell, but the activity of one cell can stimulate another. Stimuli do not determine the nature of the reaction of a cell, but merely serve to set the cell off, once it is stimulated. The character of the reaction is totally determined by the structure and physiological condition of the cell itself.

[2] Insistent because it is possible to move away from external stimuli, but internal stimuli we always have with us.

Psychology and Personality

There is a distinct difference between scientific psychology and serious personality study. It lies in the fact that in the science of psychology we are interested in developing broad generalizations about the uniform behavior of countless people. We are interested principally in average performance, typical results, uniform conditions, prediction, measurement, and control. The psychologist's laboratory is not the place where one can find a genuine interest in the individual experimented upon, as a person. Usually we attach a great deal of apparatus to the subject, get him to react to certain specified stimulus conditions, and then get rid of him as quickly as we can so that we can analyze the pointer readings arranged in neat columns and the curves that he has left inscribed on paper as a record of his responses. All this is important. There is, however, a legitimate field of human endeavor — personality study, if you will — which is interested in following through in an intimate manner the development of an integrated and organized system of habits, knowledge, attitudes, opinions, and prejudices that we know as John Jones. Personality study is thus based on general psychology, and without a knowledge of the basic principles of psychology one can accomplish little in understanding the development of any personality; but for many of its working hypotheses personality study leaves the field of general psychology to go into the special ones of child study, anthropology, social and abnormal psychology, and sociology. In order to be a competent student of personality adjustments one has to go far beyond the limitations of this book. Without this background it is hopeless to try to understand people except in the most superficial way.

It is true that many of the findings in general psychology have little or no bearing on personality study because there are equally important fields — physiology, biology, animal behavior — from which psychological researchers gain their inspiration and direction. There are other fields of general psychology — learning, maturation, motivation, perception, emotion, and the conflict-frustration area where the implications for the psychology of individual adjustment are more obvious.

First, it appears that a human infant, in common with the young of all other higher animal forms, begins life under the control of internal stimulating conditions. Most of these conditions seem to result, at first, in a restless undirected activity involving considerable muscular tension. Various external stimulating situations serve to accomplish changes in the environment which bring an end to this activity. Cessation of intense activity means muscular relaxation so that a balanced or quiescent state is reached. The relief of tension seems to be the prime prerequisite associated with learning so that whatever conditions surround the relief of these tensions are approached and appropriate activity is sought after. Whatever causes tension is avoided. When this stage is reached, we cease to say that the child is "driven," but rather speak of his behavior as "motivated." The variety of things and conditions that can serve as signals for approach reactions is positively enormous. If hunger pangs are relieved by foods of certain consistencies and flavors, then these kinds of stimuli cause approach reactions, but another child who gets different consistencies and flavors will refuse what the first prefers. Although we can observe these differences between the preferences of different families in our own culture, they are even more pronounced when we examine the preferences of different cultural groups. Since what is true for the approaching and accepting reactions is also true for avoiding and rejecting, we find wide differences between the kinds of things that people dislike. At a very early age behavior thus becomes goal-directed. The process of attaining these goals is the process of "living" as contrasted with "existing."

Language

In human beings this process is complicated by the fact that words soon come to stand as substitutes for things, and as a consequence behavior can be motivated through the use of language alone. Because of the comparative ease with which words can be manipulated, all kinds of conflicts soon arise. One such conflict involves our saying one thing and doing another. Children are quick to observe this difference between word and act, and, if it occurs, that there are wide discrepancies between these two factors in our behavior as adults. Then children learn either to react in the same way and become people in whom no dependence can be placed, or else they come to distrust members of their own families and seek the security that is found in correspondence between word and deed in friends, teachers, and associates outside the family group.

Let us digress from the main developmental theme of this section for a moment to show how in still another way language is important in personal relations. Once a person has acquired a system of words, he keeps them with him always. Although by leaving the scene of the conflict to go home or to his room, he can escape from the minor irritations or serious conflicts involved in contact with either people or things, he can not escape from carrying along with him the language responses built up in these situations. These produce the same tensions in privacy that the actual situation does — a process commonly called "worrying." As a matter of fact, the tensions produced in this process may even be more pronounced than those involved in dealing with the situation directly because certain outcomes of proposed action having no correspondence with an actual outcome can be anticipated in words. This fact is commonly observed and finds expression in the formulation "anticipation is frequently worse than realization." Anticipations can be worked out in words inviting a favorable outcome rather than an unfavorable one, and where there is a discrepancy we speak of disappointment and disillusionment.

Both of these processes — worry (anticipating an unfavorable outcome) and disillusionment (anticipating a favorable outcome and later finding it to be different) — are distinctive experiences which involve the whole psychological individual and as such have an influence on personality development. Some people develop habits of either the one kind or the other and so find themselves always in some chronic state of dissatisfaction.

Planning an outcome in words, or in word substitutes, as in drawing plans for a machine or a building or in designing a costume, is of course an invaluable activity. We could not get along without it in our civilization. It is equally obvious that our civilization could not exist if it were not possible to plan and to design. But it will also be evident that human beings have been more successful in planning for machines, structures, and clothing than for the outcome of person-to-person interrelations. The reason for this is that our plans for dealing with the nonpersonal situations have specific and definite meanings in terms of the objects and events they represent, while there is no such correspondence between our plans for dealing with people and the actual behavior of the people in question. Part of the difficulty is that people are so complex. When we try to anticipate human behavior we are in effect drawing a plan for a complicated architectural structure by scratching with a stick in the sand without benefit of highly specialized drafting tools, T-square, and drawing board. But even if we had the best tools with which to work, we would find still another factor which would interfere with our ability to plan satisfactorily our dealings with people. In terms of our analogy, it is easy to see that even today we can have idealists and impractical people working out their dream-structures on drawing boards. That these designs are impractical is due to the fact that there is no correspondence between the design on paper and the properties of the materials that will finally have to be used. By the same token, in our dealings with people we will encounter dreamers who have such idealized conceptions of human behavior that no person ever existed or can exist to correspond with the dream. Teachers expect children to sit still, ministers expect people to be honest, professors expect students to thirst for knowledge, Sunday school teachers expect people to be moral — and all this universally and absolutely without regard to special conditions. A more realistic view of these matters would have it that morality and honesty are highly specific concepts; children can't be expected to sit still in view of their metabolic rates; a thirst for knowledge has to be especially cultivated.

Human behavior does not depend upon the language formulations of teachers, moralists, novelists, poets, philosophers, lawyers, or politicians. It depends on the three factors — structure, environment, and the history of past reactions.

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SUGGESTIONS FOR FURTHER READING

Jastrow, Joseph. Lo, the pseudologist. *Esquire*, January, 1936. The author shows the real nature of certain pseudo-sciences which sometimes claim to be psychology but which the reader should avoid confusing with scientific psychology. Also reprinted in Hartley, E. L., *et al. Outside Readings in Psychology* (1st ed.). Crowell, 1950.

Ogg, Elizabeth. *Psychologists in Action*. Public Affairs Pamphlet No. 229, 1955. "An effort to set forth some of the interesting things now happening in this new science and this expanding profession." — Executive Secretary, APA.

Wisdom. May, 1957. An entire issue of this new magazine was devoted to writings from outstanding psychologists.

PART III Behavior Is Adaptive

In our complex civilization, learning and remembering are fundamental to all behavior patterns of man. The acquisition of personal skills in the young child, the development of intellectual and social skills during the school age, and the achievement of cultural satisfactions throughout life are all based on learning. We learn those activities which contribute to our economic self-support, those habits which make up our individuality, and those behaviors which are common to people in a cultural group and justify our acceptance into that group.

Psychologists have always recognized that learning is a key problem in the understanding of behavior. One of the earliest experiments attempted in the first psychological laboratory dealt with memory, and many of the "great experiments" in psychology have been concerned with the establishment of findings describing man's tremendous range of adaptability through modification of behavior. Undoubtedly more research time has gone into studies of learning than into any other problem in psychology. Modern theories of behavior, which are attempts to account for the facts on the basis of a set of systematic and consistent principles, are mainly theories of learning or theories which give great emphasis to learning. The practical importance of understanding learning has also stimulated research.

But there is a source of adaptation other than learning. Correlated with normal growth is a process known as maturation, or the development of ability in the absence of external stimulation. Several ingenious experiments have been performed to separate the contribution of learning by experience from maturation through growth. The first article in this section describes one of these experiments. The writer tells of his efforts to make clear how visual recognition skill is developed. This series of studies makes an interesting contrast with the second article, where the question is similar but the mode of attack is very different. Then selections 15 and 16 provide the reader a "visit" to two of the major centers where research on learning is taking place — Wisconsin and Harvard. Hull's article follows, and although it is a bit more difficult than the others, it is a nice description of the establishment of a law of learning. The last four selections deal with the durable character of learning — remembering. Gerard and Young tackle the great puzzle of the brain and memory. Miller wants to understand better the limiting factors in remembering, and finally Whalen summarizes some of the answers to questions frequently asked about the accuracy of memory.

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Arrested Vision

AUSTIN H. RIESEN

What role does learning play in such a fundamental behavioral skill as recognizing objects by sight? Whether visual perception is inherited, learned, or developed through maturation is a problem which has both theoretical and practical importance. We seek to understand our ability to distinguish round from square, near from far, to recognize faces and the thousands of other things we see. Riesen describes some of his experiments designed to establish the degree to which visual perception depends upon prior stimulation. The method of deprivation was employed with chimpanzees as subjects.

Dr. Riesen is associate professor of psychology at the University of Chicago and formerly taught at Yale University and at the University of Rochester. He conducted the research reported here at the Yerkes Laboratories of Primate Biology in Orange Park, Florida. This article appeared in *Scientific American* in July, 1950 (pp. 16–19), and is reprinted by permission of the publisher.

Many primitive organisms show immediate and highly uniform reactions to light from the moment of birth. In man vision is a much more complex skill that develops gradually through the years of infancy and childhood. How much of this capacity is innate and how much is acquired by learning or through the natural maturation of the eyes during the child's early years? What are the factors that determine visual perception? If we knew the answers to these questions we could do a great deal more than we can now to improve defective vision.

The task of separating the hereditary factors from the effects of experience in human vision obviously is not easy. For example, a newborn infant at first shows no clear indication of any response to a bright disk presented before its eyes. Only after several weeks does the growing infant begin to look at the disk. Is this the result of growth, of experience or of both? Does the change in response come about through practice in the use of the eyes, or through a natural maturation that occurs, quite independently of use, in the retina of the eye, in the eye or neck muscles, in fiber tracts of the central nervous system or in several of these parts combined?

Scientific studies of the growth of behavior have shown that certain abilities do develop without use as animals mature. Thus tadpoles raised under anesthesia to prevent swimming movements nevertheless improve in swimming ability. Chicks and rats kept in darkness for a time show some progress in vision-controlled behavior. Children also demonstrate a basic rate of maturation in some capacities: there is a limit to the degree of retardation or acceleration of these abilities that can be effected by restricting or expanding their training.

But some of these studies have revealed curious contradictions. Wendell Cruze at North Carolina State College found that after newly hatched chicks had been kept in darkness for five days, they were generally able to peck at and hit 24 of the first 25 grains presented to them; this score was 12 per cent better than the average of hits by chicks immediately after hatching. On the other hand, S. G. Padilla at the University of Michigan showed that if the period of darkness was extended to 14 days, the pecking response failed to appear, presumably because the instinct to peck at spots on the ground died out through disuse. The chicks began to starve in the midst of plenty. So it appears that lack of practice, at least if sufficiently prolonged, can interfere with the development of behavior which is basically instinctive or reflex in nature.

In human beings the most nearly pertinent evidence on this problem has come from studies of patients operated upon at advanced ages for congenital cataracts. These patients, who have passed all their lives in near-blindness, ranging from the bare ability to tell day from night to some ability to distinguish colors and localize light, invariably report an immediate awareness of a change after a successful operation. They begin at once to distinguish differences in the parts of the visual field, although they cannot identify an object or describe its shape. After a few days' practice they can name colors. From this point on progress is slow, often highly discouraging, and some patients never get beyond the ability to distinguish brightness and color. Others, over a period of months and even years, develop the ability to identify simple geometric figures, read letters and numbers and, in rare cases, to identify complex patterns such as words, outline drawings and faces. During their efforts to improve their visual skill the patients go through a long period of picking out elements in an object and inferring the nature of the object from these elements — often erroneously. For example, a child of 12, some months after her operation, is reported by her doctor to have pointed to a picture and called it "a camel, because it has a hump." What she identified as a hump was the dorsal fin of a fish.

But such cases of congenital cataract do not give us very satisfactory evidence on the elementary problem of how disuse affects the development of visual behavior. There are too many other variables we must take into account (1) the degree of the patient's previous blindness, since he was not in total darkness, (2) the limit that is imposed on his potentialities for improvement by the fact that the eye operated on lacks a lens, and (3) the circumstance that in all these cases there appears to be another visual handicap — jerky movements of the eyeballs known as spontaneous nystagmus. The effects of these combined difficulties are not readily calculable. For a more meaningful study it is highly desirable to eliminate these variables by setting up a controlled experiment that will determine the effects of disuse on normal eyes. Obviously such an experiment cannot be risked in human beings; no one would wish to impose permanent reading difficulties on any person having to adjust himself to a civilized society. The most logical subject for the experiment is another higher primate. The chimpanzee was chosen, because its behavior, like man's, is dominated by vision, and because it is intelligent and tractable.

In 1942 at the Yerkes Laboratories of Primate Biology in Orange Park, Fla., an infant male chimpanzee was separated from its mother on the day of birth and blindfolded with a gauze bandage and adhesive tape. This animal defeated the experimenters by loosening the tape at the side of his left nostril and habitually peeking down his nose with his left eye. By the age of 16 weeks he gained full freedom from facial bandages. Although he did not recognize his feeding bottle at this time, nor show fixation of persons or objects, he developed fairly adequate visual behavior within a few weeks.

In 1945 the experimenters tried again. This time two newborn chimpanzee infants, a male and a female respectively named Snark and Alfalfa, were housed in a completely darkened room. During the first 16 months the only light these infants experienced was an electric lamp turned on for intervals of 45 seconds several times daily for their routine care and feeding. When they were first tested for visual perception at the age of 16 months, both chimpanzees showed extreme incompetence. Their reflex responses indicated that their eyes were sensitive to light — the pupils constricted; sudden changes of illumination startled the animals; they responded to a slowly waving flashlight with jerky pursuit movements of the eyes and side to side following motions of the head. But both chimpanzees failed to show any visual responses to complex patterns of light until after they had spent many hours in illuminated surroundings. They did not respond to play objects or their feeding bottles unless these touched some part of the body. They did not blink at a threatening motion toward the face. When an object was advanced slowly toward the face, there was no reaction until the object actually touched the face, and then the animal gave a startled jump.

After the 16-month period of darkness, Alfalfa was placed on a limited light schedule until the age of 21 months and Snark until 33 months. When Alfalfa was later moved into a normal daylight environment, in the course of many months she developed normal recognition of objects, began to blink in response to threats and ceased to be startled by a touch. Snark was much more retarded. Between the ages of 20 and 27 months, while he was still on rationed light, he learned after many hundreds of trials to tell the difference between contrasting signs, differing in color or pattern, which indicated either food or a mild electric shock. His visual acuity, as measured by ability to discriminate between horizontal and vertical lines, was well below that of normally raised animals. At the end of 33 months he began to live in the normally lighted chimpanzee nursery and later out of doors with chimpanzees of his own age. It was expected that he would rapidly acquire normal visual behavior. He did improve slightly at first, but after this small initial improvement he actually lost ground in visual responsiveness, until even reflex activity began to die away.

What is the explanation of this deterioration? Had the development of his eyes been permanently arrested by the absence of light? There had been no previous evidence that stimulation by light is essential for the normal growth of the primate retina or optic nerve. It was a surprise to find that, while the eyes of these chimpanzees remained sensitive to light after 16 months in darkness, the retina and optic disk in both animals did not reflect as much light as normal chimpanzee eyes do. Snark later developed a marked pallor of the optic disk in both eyes. There is other evidence suggesting that fish and amphibians, at least, need light-stimulation for normal eye development. So the physiological effects of the lack of light may be part of the explanation for Snark's loss of visual function. But it is not the whole explanation for all the visual abnormalities in these two chimpanzees, nor does it explain the visual difficulties of the cataract patients. These patients have excellent color discrimination, and, incidentally, do not show pallor of the optic disk. Moreover, we now have clear evidence from further experiments with chimpanzees that not merely light itself but stimulation by visual patterns is essential to normal visual development.

In these experiments three other newborn chimpanzees, two females and a male, were put into the darkroom. Debi was raised for seven months in complete darkness, even during her feedings and other care. Kora was raised for the same period on a ration of an average of one and a half hours of light daily, but the light, admitted through a white Plexiglas mask, was diffuse and unpatterned. Lad was given one and a half hours of patterned light daily: he could observe the edges of his crib, the variations in pattern introduced by movements of his own body and appendages, and all the accompaniments of bottle-feeding, including the moving about of persons in the moderately lighted room.

At seven months, when the three subjects were removed to normal daylight surroundings, Lad's visual performance was indistinguishable from that of chimpanzees raised normally. Kora and Debi, however, showed the same kinds of retardation as had Snark and Alfalfa, with some minor exceptions. Kora did not develop the blink response to a moving object until six days after her removal from darkness, and Debi not until 15 days. It took Kora 13 days and Debi 30 days to acquire the ability to pursue a moving person with the eyes, and they did this by a series of refixations instead of following smoothly as normal animals of comparable age do; it took Kora 20 days and Debi 16 days to pursue visually a moving feeding bottle; Kora 13 days and Debi 30 days to fixate the image of a stationary person.

These differences between Debi and Kora may lie within the range of variation that would occur in a group of animals treated exactly the same as either Debi or Kora. This question could be checked only by repeating the experiment many times.

Between seven and 10 months of age Debi and Kora both showed a moderate and intermittent outward (wall-eyed) deviation of the eyes. This gradually was overcome. Both infants also showed an initial spontaneous nystagmus, *i.e.*, jerky eye movements. It appeared only sporadically, and was more pronounced under general excitement than when the animals were well relaxed.

Normal animals of seven months learn to avoid a large yellow and black striped disk after receiving one or two mild electric shocks from it. Debi and Kora, however, were shocked by the disk twice a day for six and nine days respectively, before they so much as whimpered when it was shown. Only after 13 days in Kora's case and 15 days in Debi's did they consistently indicate by some sort of avoidance response that they saw the disk within five seconds of the time that it was raised in front of their eyes.

In still another study an infant chimpanzee named Kandy was put in the darkroom for only the first three months of life. After she was removed to daylight surroundings, her progress on the same tests was approximately parallel to that of Debi and Kora. There were three interesting differences: (1) Kandy showed a convergent squint (cross-eyes), which cleared up in a little less than two months; (2) she did not have spontaneous nystagmus; (3) she required 24 days, as compared with 13 or 15, to develop consistent avoidance of the black and yellow shock-disk. The last difference suggests that Kandy learned more slowly because of her younger age; in other words, that the development of visual discrimination was a matter of maturity as well as learning. This conclusion was strongly supported by the finding that an infant chimpanzee started through the same training at the age of two days failed to show avoidance in a month's time.

All these observations demonstrate that vision must be put to use if it is to develop normally, but they also indicate that during the first few months of an infant's life visual development is advanced by growth factors which are entirely independent of practice. Normally reared animals, for example, do not blink in response to the movement of objects across the visual field until they have reached the age of two months; the older darkroom animals, despite previous lack of experience, began to show this response within about two weeks after they were transferred to daylight surroundings.

The development and maintenance of normal visual functions in higher primates depends on a whole complex of interrelated factors, hereditary and environmental, and it can readily be disturbed at any stage of the individual's growth. This was shown in an experiment with a chimpanzee named Faik. Faik was raised in the normal light of the laboratory's nursery until the age of seven months. At that time the standard series of tests described above showed that he had excellent use of vision. Then from the age of eight to 24 months he was kept in the darkroom. He lived an active life filled with tactile, auditory, olfactory, gustatory and kinesthetic stimulation. He invited rough-house play from his caretakers at feeding times, and his general state of health remained entirely satisfactory.

When Faik was returned to daylight living quarters at 24 months, he had lost all ability to utilize vision in his interplay with the environment. He no longer recognized the feeding bottle, and failed to look at objects or persons, either stationary or moving. More than this, he possessed a strong spontaneous nystagmus and was even unable to follow a moving light in a darkroom until the fifth day after he was put back into a lighted environment. His first visual following movements, like those of all the darkroom-raised subjects, were not smooth but a series of jerky refixations, made even more jerky by the pronounced spontaneous nystagmus.

Even in direct sunlight Faik failed to grimace or close his eyelids; he gave no indication of the slightest discomfort when the sun shone in his eyes. (The chimpanzees raised in the darkroom from birth did close their lids in intense light.) Faik showed pallor similar to that of Snark and Alfalfa in his optic disks. His recovery of vision has been slow and is still only partial. Explanation of his case, and that of Snark, remains a challenge to further research.

These chimpanzee studies have established several fundamental points. They show that newborn animals, and older infants that have been kept in darkness for a time, exhibit visual reflexes when they are first subjected to light. Some responses that bear a close resemblance to reflex behavior, such as blinking at something rapidly approaching the face, become automatic only after considerable practice. Visual pursuit of moving objects, the coordination of the two eyes and convergent fixation, and the first recognition of objects come only after many hours or weeks of experience in use of the eyes. It takes the chimpanzee hundreds of hours of active utilization of the eyes to develop its vision to the stage where it can adequately guide locomotion and complex manipulations. The findings in the cases of two subjects that were kept in darkness for long periods indicate that the postponement of light exposure for too long can result in making the development of normal visual mechanisms extremely difficult if not impossible.

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The Involuntary Bet

WILLIAM H. ITTELSON

Studies dealing with the problem of modification of perception through learning may be made with infant chimpanzees as was done in the research by Riesen, or by using human subjects and deliberately modifying stimulus relationships, as in the demonstrations described here by Ittelson. Both Riesen and Ittelson have shown that perception is dependent upon experience to an important degree. Ittelson structures the perceptual process in terms of the observer's making judgments on the basis of probabilities derived from prior learning. When a new perceptual event does not "check out" with expectation, we may modify our probability estimates and thus alter perception. Since the physical world is normally orderly, we do not fully appreciate these principles, but when we encounter disarrangement and distortion, such as Ittelson describes, the principles become clear.

The author is associate professor of psychology at Brooklyn College and formerly taught at Princeton. He was originally an electrical engineer. This article is reprinted from *Vogue*, March 15, 1952 (pp. 76–77, 128). Copyright, 1952, the Condé Nast Publications, Inc.

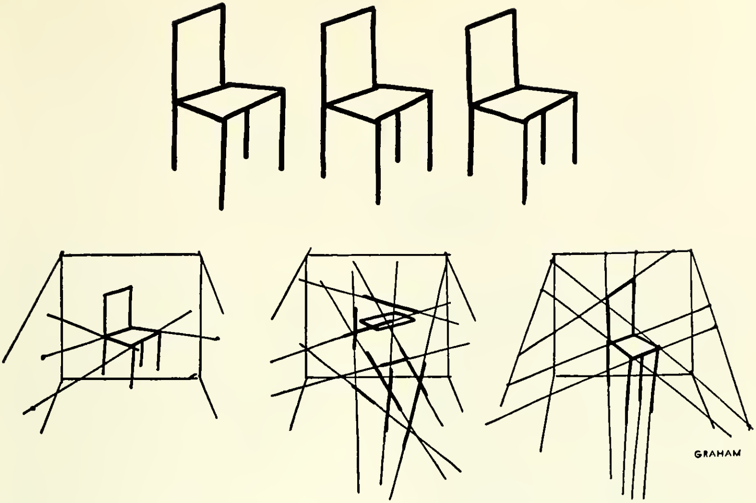
How and why do we see the people and things around us? Trying to answer this question — technically called the study of perception — may seem at first glance to be a trivial task. But understanding this simple fact, perhaps just because it is one of the most universal and basic of human experiences, is by no means simple. Ask yourself, for example, why the chair across the room looks the way it does. And does it look the same to someone else? If not, how can either of you know what it really is like? Or how can you ever come to any sort of agreement or decision about the chair? It is just such questions as these that psychologists studying perception are trying to answer. And while they may seem trivial when asked about a chair, their importance is obvious if we ask them of more complicated perceptions, such as those of the men about a conference table in the United Nations.

Of all the work being done in the study of perception today, beyond any doubt the most fascinating is that of a scientist in Hanover, New Hampshire, Adelbert Ames, junior, who is today actively collaborating with some of the members of the psychology department at Princeton University in designing new experiments and extending our understanding of this important no-man's-land, the psychology of perception. In commenting on Ames's work, Dr. Allan Gregg, vice-president of the Rockefeller Foundation, has said, as quoted in a recent book, *The Rockefeller Foundation*, by R. B. Fosdick, "I think Ames will be rediscovered in future years as often as anyone the Medical Sciences Division has aided."

Ames believes that his experiments, four of which are described on these pages, show that every perception we have, even of the chair across the room, is essentially an "involuntary bet." These bets are based on the probabilities each of us has learned through previous experiences with similar situations. To the extent that several people have had similar experiences, they will tend to make the same bets, to see the same things. If they have had different experiences, they will tend to see things differently. And since every perception is basically a bet, it can, like any bet, be wrong on occasion. The only way we can tell if any particular perception, any one bet, is right or wrong is by acting on it. If we are successful, the bet was "right." If we fail, it was "wrong."

1. *The Three Chairs* experiment, from the outside, looks like a big, black box, about the size of two large office desks placed one on top of the other. Along one side of this box are three small peepholes through which one can look into the interior of the box. Looking through each of these peepholes, the observer sees what appears to be the same chair, dimly illuminated inside the completely dark box. The chair seems to be made of heavy wires, but otherwise it looks like an ordinary, solid, well-built chair. The seat is flat, the legs and back are straight, and it sits squarely on the floor. After the observer has noted this through each of the peepholes, he walks to the back of the box, which is open so that he can see what is really inside. To his amazement, he discovers that only one of these objects actually is a wire chair. The other two resemble nothing more than weird wire cobwebs. In each case, what the observer sees does not correspond to what is really there. The three-dimensional "chairness" which he experiences does not exist in the physical objects at which he is looking. After finding out what is actually in the box, the observer can go back and look through the peepholes again. *He still sees the same solid wire chairs* [figure, p. 77].

2. *The Leaf Room* experiment, as its name suggests, consists of a small room, the inside of which is completely covered with leaves. An ob-



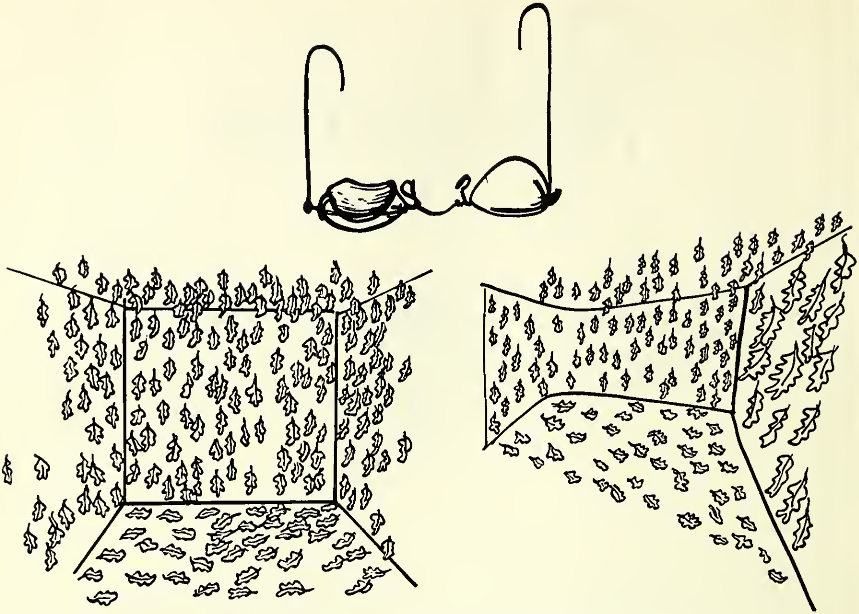
Experiment I. Upper: Chairs as they appeared to the viewer. Lower: As they actually were made.

server looks into this room carefully, is allowed to examine it and even to walk in it. He then looks at it while wearing a specially designed pair of aniseikonic glasses which have the peculiar property of altering some of the visual indications he is receiving while not affecting others. Now the room assumes weird and fantastic shapes. The leaves and walls change size and shape and appear to move mysteriously under their own power. The observer becomes confused, bewildered. When asked to walk into the room, he may become terrorized and remain frozen to his seat. Even if he does enter the room, he does so hesitatingly. He can not walk steadily. He is unable to touch objects when he reaches for them. He can not very well describe the room because it seems always to be changing.

For most people this experience is quite disturbing and even frightening. It is frequently described as a "nightmare." Sometimes, if the observer looks at an ordinary, familiar room, instead of the "leaf room," the glasses have little or no effect, and the experience is not at all disturbing. Occasionally, an observer seems to enjoy wearing the glasses even in the "leaf room," but this reaction is most often seen in children. For children, wearing the glasses is better than a party. They laugh and squeal as they go through experiences which terrify many adults. They not only do not mind, but they seem actually to delight in having their own world turned topsy-turvy.

It is interesting that in this demonstration, as in everyday life, no matter how confusing the situation may be, no matter how extreme the conflicts, most people manage to make some decision, to arrive at what seems to be the "best bet" under the circumstances [figure, p. 78].

3. *The Distorted Room* is a model, about the size of a large packing case, of a crazily built room. The floor slopes down, the ceiling slopes up, the back wall slopes away. All the walls are different sizes and shapes. But this peculiar room has one important property — from one *point of view* it looks like an ordinary rectangular room. The observer is shown the room in detail before he looks at it from the viewing position. He examines its construction, shape, and size carefully until he becomes quite familiar with it. No attempt is made to fool him, on the contrary, every effort is made to have him learn all that he can about the room. When the observer is satisfied that he knows the room thoroughly, he sits at the viewing point. The room now appears to be perfectly rectangular while familiar objects, such as a pair of hands, appear distorted. He experiences a conflict between what he sees and what he knows, accompanied by a sense of confusion and uncertainty. Now the observer is given a pointer and



Experiment II. Leaf room (left), distorted by glasses into nightmare (right).

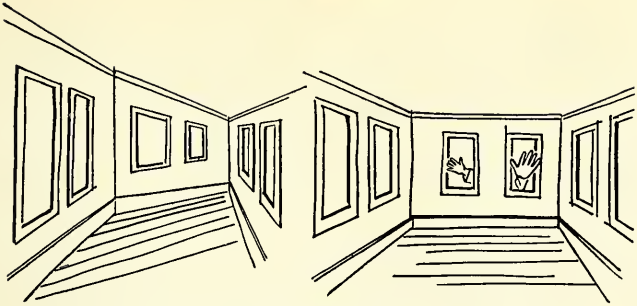
told to hit a spot on one of the side walls as if he were swatting a fly. He confidently swings but misses, wildly smashing the pointer into the back wall [figure, p. 79].

No matter how much a person knows about the true shape of the room, when asked to do something in it, he acts, not on what he *knows*, but rather on what he *sees*. It would seem, therefore, that the bets we make, which determine what we see, are really guesses as to the probable results of acting in the particular situation. We can check our perceptions, find out if our bets are right or wrong, only through action.

In life's constant sequence of checking by acting, the role of failure, of unsuccessful action, is as important as that of success. Success can only confirm what we already know, while failure points out our inadequacies and opens up opportunities for change and development toward greater adequacy. The overprotected child is a familiar example of a person denied this opportunity by never being allowed to experience the consequences of his own actions.

The way a person reacts to a failure is an indication of that person's potentialities for development and growth. In the distorted room, for example, initial failure in "swatting the fly" quickly makes the observer much more able to act in the room than he ever would have been if he just sat and looked at it. But different people react quite differently. Most observers keep on trying after the first failure, some with grim determination, some with nervous embarrassment, and a few with real, wholehearted enjoyment. At the other extreme are those who refuse to try again at all. A few observers have been known to throw the pointer down and stalk from the experimental room in a fury.

4. *The Rotating Trapezoid* consists of a trapezoidal piece of sheet metal or cardboard, with holes cut in it and shadows painted on it to give the appearance of a window. It is mounted on a rod connected to a motor which rotates it continuously about a vertical axis. When an observer views this device, however, he does not see a rotating trapezoid, but instead an oscillating rectangular window, swinging back and forth through an arc of about 100 degrees. A particularly inter-

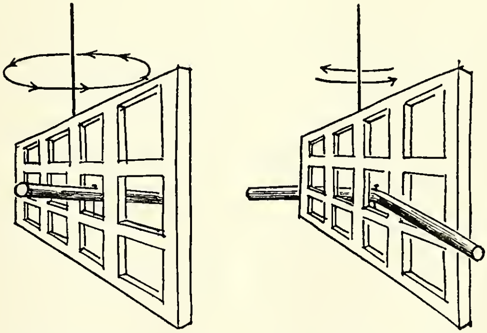


Experiment III. Distorted room (left); the illusion of normalcy (right).

esting effect can be seen if a solid tube is inserted in the window through one of the openings. Part of the time the tube and the window appear to be swinging in opposite directions so that at one point they seem to hit head on. Different observers see different things when this happens. Some see the tube remain absolutely rigid and appear to cut its way through the window frame. To others, the tube seems to be flexible, so that it appears to stretch out and bend around the window. Here is an important laboratory proof that when different people make different "bets" about the same situation they experience that situation differently. *They literally live in different worlds* [figure, below].

In one especially interesting experiment using the rotating trapezoid, observers were shown and allowed to feel a steel tube and told that it would be put on the window. They were later shown and handed a rubber tube and told the same thing. Actually a third, wood tube was placed in the window both times. Most observers, however, saw the "steel" tube remain rigid and cut through the window while they saw the "rubber" tube stretch and bend around. Since they had had very little experience in situations like this, the bets they made were quite tentative and easily changed by suggestion or "propaganda."

Such bets are essentially predictions of the results of future actions, based on the probabilities learned from acting in the past. This means that people can pick out of a welter of conflicting possibilities those actions that have the highest probability of being successful. And when we recognize that people never act in a vacuum, that they always act for some purpose of greater or lesser value to them, we can see that the study of perception may eventually help increase our understanding of basic human values.



Experiment IV. Actually a revolving object; the illusion (right) and oscillating object.

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Learning to Think

HARRY F. HARLOW AND MARGARET K. HARLOW

Where does the ability to learn come from? Many educators, psychologists, and other scholars have believed that learning ability is innate — you inherited more or less of it and you could no more change it than you could change the color of your eyes. In a series of studies using children and monkeys, the Harlows and their students believe they have demonstrated just the opposite — we learn to learn. Organisms begin with a fumbling, crude, blind, random effort to learn. By building up organized patterns of responses through experience we develop what the authors call "learning sets." It is a skilled learning set which permits the high-level type of performance known as "insightful" performance. This article also contains some more good answers to the question, "Why do psychologists use animals so much?"

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How does an infant, born with only a few simple reactions, develop into an adult capable of rapid learning and the almost incredibly complex mental processes known as thinking? This is one of psychology's unsolved problems. Most modern explanations are not much more enlightening than those offered by 18th-century French and English philosophers, who suggested that the mind developed merely by the process of associating ideas or experiences with one another. Even the early philosophers realized that this was not a completely adequate explanation.

The speed and complexity of a human being's mental processes, and the intricacy of the nerve mechanisms that presumably underlie them, suggest that the brain is not simply a passive network of communications but develops some kind of organization that facilitates learning and thinking. Whether such organizing principles exist has been a matter of considerable dispute. At one extreme, some modern psychologists deny that they do and describe learning as a mere trial-and-error process — a blind fumbling about until a solution accidentally appears. At the other extreme, there are psychologists who hold that people learn through an innate insight that reveals relationships to them.

To investigate, and to reconcile if possible, these seemingly antagonistic positions, a series of studies of the learning process has been carried out at the University of Wisconsin. Some of these have been made with young children, but most of the research has been on monkeys.

For two basic reasons animals are particularly good subjects for the investigation of learning at a fundamental level. One is that it is possible to control their entire learning history: the psychologist knows the problems to which they have been exposed, the amount of training they have had on each, and the record of their performance. The other reason is that the animals' adaptive processes are more simple than those of human beings, especially during the first stages of the attack on a problem. Often the animal's reactions throw into clear relief certain mechanisms that operate more obscurely in man. Of course this is only a relative simplicity. All the higher mammals possess intricate nervous systems and can solve complex problems. Indeed, it is doubtful that man possesses any fundamental intellectual process, except true language, that is not also present in his more lowly biological brethren.

Tests of animal learning of the trial-and-error type have been made in innumerable laboratories. In the special tests devised for our experiments, we set out to determine whether monkeys could progress from trial-and-error learning to the ability to solve a problem immediately by insight.

One of the first experiments was a simple discrimination test. The monkeys were confronted with a small board on which lay two objects different in color, size and shape. If a monkey picked up the correct object, it was rewarded by finding raisins or peanuts underneath. The position of the objects was shifted on the board in an irregular manner from trial to trial, and the trials were continued until the monkey learned to choose the correct object. The unusual feature of the experiment was that the test was repeated many times, with several hundred different pairs of objects. In other words, instead of training a monkey to solve a single problem, as had been done in most previous psychological work of this kind, we trained the animal on many problems, all of the same general type, but with varying kinds of objects.

When the monkeys first faced this test, they learned by the slow, laborious, fumble-and-find process. But as a monkey solved problem after problem of the same basic kind, its behavior changed in a most dramatic way. It learned each new problem with progressively greater efficiency, until eventually the monkey showed perfect insight when faced with this particular kind of situation — it solved the problem in one trial. If it chose the correct object on the first trial, it rarely made an error on subsequent trials. If it chose the incorrect object on the first trial, it immediately shifted to the correct object, and subsequently responded almost perfectly.

Thus the test appeared to demonstrate that trial-and-error and insight are but two different phases of one long continuous process. They are not different capacities, but merely represent the orderly development of a learning and thinking process.

A long series of these discrimination problems was also run on a group of nursery-school children two to five years of age. Young children were chosen because they have a minimum of previous experience. The conditions in the children's tests were only slightly different from those for the monkeys: they were rewarded by finding brightly colored macaroni beads instead of raisins and peanuts. Most of the children, like the monkeys, made many errors in the early stages of the tests and only gradually learned to solve a problem in one trial. As a group the children learned more rapidly than the monkeys, but they made the same types of errors. And the "smartest" monkeys learned faster than the "dullest" children.

We have called this process of progressive learning the formation of a "learning set." The subject learns an organized set of habits that enables him to meet effectively each new problem of this particular kind. A single set would provide only limited aid in enabling an animal to adapt to an ever-changing environment. But a host of different learning sets may supply the raw material for human thinking.

We have trained monkeys and children to solve problems much more complex than the ones thus far described. For instance, a deliberate attempt is made to confuse the subjects by reversing the conditions of the discrimination test. The previously correct object is no longer rewarded, and the previously incorrect object is always rewarded. When monkeys and children face this switchover for the first time, they make many errors, persistently choosing the objects they had previously been trained to choose. Gradually, from problem to problem, the number of such errors decreases until finally the first reversal trial is followed by perfect performance. A single failure becomes the cue to the subject to shift his choice from the object which has been rewarded many times to the object which has never been rewarded before. In this type of test children learn much more rapidly than monkeys.

A group of monkeys that had formed the discrimination-reversal learning set was later trained on a further refinement of the problem. This time the reward value of the objects was reversed for only one trial, and was then shifted back to the original relationship. After many problems, the monkeys learned to ignore the single reversal and treated it as if the experimenter had made an error!

The problem was made more complicated, in another test, by offering the subjects a choice among three objects instead of two. There is a tray containing three food wells. Two are covered by one kind of object, and the third is covered by another kind. The animal must choose the odd object. Suppose the objects are building blocks and funnels. In half the trials, there are two blocks and a funnel, and the correct object is the funnel. Then a switch is made to two funnels and one block. Now the correct object is the block. The animal must learn a subtle distinction here: it is not the shape of the object that is important, but its relation to the other two. The meaning of a specific object may change from trial to trial. This problem is something like the one a child faces in trying to learn to use the words "I," "you," and "he" properly. The meaning of the words changes according to the speaker. When the child is speaking, "I" refers to himself, "you" to the person addressed, and "he" to some third person. When the child is addressed, the child is no longer "I" but "you." And when others speak of him, the terms shift again.

Monkeys and children were trained on a series of these oddity problems, 24 trials being allowed for the solution of each problem. At first they floundered, but they improved from problem to problem until they learned to respond to each new problem with perfect or nearly perfect scores. And on this complex type of problem the monkeys did better than most of the children!

One of the most striking findings from these tests was that once the monkeys have formed these learning sets, they retain them for long periods and can use them appropriately as the occasion demands. After a lapse of a year or more, a monkey regains top efficiency, in a few minutes or hours of practice, on a problem that it may have taken many weeks to master originally.

All our studies indicate that the ability to solve problems without fumbling is not inborn but is acquired gradually. So we must re-examine the evidence offered in support of the theory that animals possess some innate insight that has nothing to do with learning.

The cornerstone of this theory is the work of the famous Gestalt psychologist Wolfgang Köhler on the behavior of chimpanzees. In a series of brilliant studies he clearly showed that these apes can use sticks to help them obtain bananas beyond their reach. They employed the sticks to knock the bananas down, to rake them in, to climb and to vault. The animals sometimes assembled short sticks to make a pole long enough to reach the food, and even used sticks in combination with stacked boxes to knock down high-dangling bait. That the chimpanzees frequently solved these problems suddenly, as if by a flash of insight, impressed Köhler as evidence of an ability to reason independently of learning. He even suggested that this ability might differentiate apes and men from other animals.

Unfortunately, since Köhler's animals had been captured in the jungle, he had no record of their previous learning. Recent studies on chimpanzees born in captivity at the Yerkes Laboratory of Primate Biology at Orange Park, Fla., throw doubt on the validity of Köhler's interpretations. Herbert Birch of the Yerkes Laboratory reported that when he gave sticks to four-year-old chimps in their cages, they showed little sign at first of ability to use them as tools. Gradually, in the course of three days, they learned to use the sticks to touch objects beyond their reach. Later the animals solved very simple stick problems fairly well, but they had difficulty with more complex problems.

Extending Birch's investigations, the late Paul Schiller presented a series of stick tasks to a group of chimpanzees from two to over eight years of age. The younger the animal, the more slowly it mastered the problems. Some young subjects took hundreds of trials to perform efficiently on even the simplest problems, while old, experienced animals solved them with little practice. None of the apes solved the tasks initially with sudden insight.

Even at the human level there is no evidence that children possess any innate endowment that enables them to solve tool problems with insight. Augusta Alpert of Columbia University tried some of Köhler's simple chimpanzee tests on bright nursery-school children. The younger children typically went through a trial-and-error process before solving the problems. Some of them failed to solve the easiest problem in the series in five experimental sessions.

Eunice Mathieson presented more difficult Köhler-type tasks to a group of University of Minnesota nursery-school children. The results were even more overwhelmingly against the notion that tool problems are solved by flashes of natural insight. The children rarely solved a problem without making many mistakes.

This research, then, supports our findings. In all clear-cut tests — that is, whenever the animals' entire learning history is known — monkeys, apes and children at first solve problems by trial and error. Only gradually does such behavior give way to immediate solutions.

We began by pointing out that psychologists have sought to find in the higher mental processes some organizing mechanism or principle that would explain learning and thinking. We can now suggest such a mechanism: the learning set. Suppose we picture mental activity as a continuous structure built up, step by step, by the solution of increasingly difficult problems, from the simplest problem in learning to the most complex one in thinking. At each level the individual tries out various responses to solve each given task. At the lowest level he selects from unlearned responses or previously learned habits. As his experience increases, habits that do not help in the solution drop out and useful habits become established. After solving many problems of a certain kind, he develops organized patterns of responses that meet the demands of this type of situation. These patterns, or learning sets, can also be applied to the solution of still more complex problems. Eventually the individual may organize simple learning sets into more complex patterns of learning sets, which in turn are available for transfer as units to new situations.

Thus the individual learns to cope with more and more difficult problems. At the highest stage in this progression, the intelligent human adult selects from innumerable, previously acquired learning sets the raw material for thinking. His many years of education in school and outside have been devoted to building up these complex learning sets, and he comes to manipulate them with such ease that he and his observers may easily lose sight of their origin and development.

The fundamental role that language plays in the thinking process may be deduced easily from our experiments. They suggest that words are stimuli or signs that call forth the particular learning sets most appropriate for solving a given problem. If you listen to yourself "talk" while you are thinking, you will find that this is exactly what is happening. You review the different ways of solving a problem, and decide which is the best. When you ask a friend for advice, you are asking him to give you a word stimulus which will tell you the appropriate learning set or sets for the solution of your problem.

This principle is particularly well illustrated by some of our monkey experiments. Though monkeys do not talk, they can learn to identify symbols with appropriate learning sets. We have trained our monkeys to respond to signs in the form of differently colored trays on which the test objects appear. In one test the monkeys were presented with three different objects — a red U-shaped block, a green U-shaped block and a red cross-shaped block. Thus two of the objects were alike in form and two alike in color. When the objects were shown on an orange tray, the monkeys had to choose the green block, that is, the object that was odd in color. When they were shown on a cream-colored tray, the animals had to choose the cross-shaped block, that is, the object odd in form. After the monkeys had formed these two learning sets, the color cue of the tray enabled them to make the proper choice, trial after trial, without error. In a sense, the animals responded to a simple sign language. The difficulty of this test may be judged by the fact that the German neurologist Kurt Goldstein, using similar tests for human beings, found that people with organic brain disorders could not solve such tasks efficiently.

At the Wisconsin laboratories, Benjamin Winsten devised an even more difficult test for the monkeys. This problem tested the animals' ability to recognize similarities and differences, a kind of task frequently used on children's intelligence tests. Nine objects were placed on a tray and the monkey was handed one of them as a sample. The animal's problem was to pick out all identical objects, leaving all the rest on the tray. In the most complicated form of this test the monkey was given a sample which was not identical with the objects to be selected but was only a symbol for them. The animal was handed an unpainted triangle as a sign to pick out all red objects, and an unpainted circle as a sign to select all blue objects. One monkey learned to respond almost perfectly. Given a triangle, he would pick every object with any red on it; given a circle, he selected only the objects with blue on them.

All these data indicate that animals, human and subhuman, must learn to think. Thinking does not develop spontaneously as an expression of innate abilities; it is the end result of a long learning process. Years ago the British biologist, Thomas Henry Huxley, suggested that "the brain secretes thought as the liver secretes bile." Nothing could be further from the truth. The brain is essential to thought, but the untutored brain is not enough, no matter how good a brain it may be. An untrained brain is sufficient for trial-and-error, fumble-through behavior, but only training enables an individual to think in terms of ideas and concepts.

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How to Teach Animals

B. F. SKINNER

The author of this article tells how to apply the principles of conditioning to the training of pets. Various elaborations of simple conditioning can be demonstrated on your own household animals, but it requires learning and practice on the part of the experimenter as well as the subject. It would pay to read the article twice — once for its instructions on training your dog, and once to look for the principles of learning which support these procedures. Our understanding of the conditioning process has increased rapidly in recent years as a result of hundreds of research studies in many laboratories. At the end of this article Dr. Skinner explains one illustration of real-life learning in terms of reinforcement theory, which has come from such research.

Dr. Skinner's name is associated with much of the modern research on the learning process. He has been a member of the faculty at Minnesota and Indiana universities, and professor of psychology at Harvard since 1948. *Scientific American* carried this article in its issue of December, 1951 (pp. 26–29). It is reprinted by permission of the publisher.

Teaching, it is often said, is an art, but we have increasing reason to hope that it may eventually become a science. We have already discovered enough about the nature of learning to devise training techniques which are much more effective and give more reliable results than the rule-of-thumb methods of the past. Tested on animals, the new techniques have proved superior to traditional methods of professional animal trainers; they yield more remarkable results with much less effort.

It takes rather subtle laboratory conditions to test an animal's full learning capacity, but the reader will be surprised at how much he can accomplish even under informal circumstances at home. Since nearly everyone at some time or other has tried, or wished he knew how, to train a dog, a cat or some other animal, perhaps the most useful way to explain the learning process is to describe some simple experiments which the reader can perform himself.

"Catch your rabbit" is the first item in a well-known recipe for rabbit stew. Your first move, of course, is to choose an experimental subject. Any available animal — a cat, a dog, a pigeon, a mouse, a parrot, a chicken, a pig — will do. (Children or other members of your family may also be available, but it is suggested that you save them until you have had practice with less valuable material.) Suppose you choose a dog.

The second thing you will need is something your subject wants, say food. This serves as a reward or — to use a term which is less likely to be misunderstood — a "reinforcement" for the desired behavior. Many things besides food are reinforcing — for example, simply letting the dog out for a run — but food is usually the easiest to administer in the kind of experiment to be described here. If you use food, you must of course perform the experiment when the dog is hungry, perhaps just before his dinnertime.

The reinforcement gives you a means of control over the behavior of the animal. It rests on the simple principle that whenever something reinforces a particular activity of an organism, it increases the chances that the organism will repeat that behavior. This makes it possible to shape an animal's behavior almost as a sculptor shapes a lump of clay. There is, of course, nothing new in this principle. What is new is a better understanding of the conditions under which reinforcement works best.

To be effective a reinforcement must be given almost simultaneously with the desired behavior; a delay of even one second destroys much of the effect. This means that the offer of food in the usual way is likely to be ineffective; it is not fast enough. The best way to reinforce the behavior with the necessary speed is to use a "conditioned" reinforcer. This is a signal which the animal is conditioned to associate with food. The animal is always given food immediately after the signal, and the signal itself then becomes the reinforcer. The better the association between the two events, the better the result.

For the conditioned reinforcer you need a clear signal which can be given instantly and to which the subject is sure to respond. It may be a noise or a flash of light. A whistle is not effective because of the time it takes to draw a breath before blowing it. A visual signal like a wave of the arm may not always be seen by the animal. A convenient signal is a rap on a table with a small hard object or the noise of a high-pitched device such as a "cricket."

You are now ready to start the experiment with your dog. Work in a convenient place as free as possible from distraction. Let us say that you have chosen a "cricket" as your conditioned reinforcer. To build up the effect of the reinforcer begin by tossing a few scraps of food, one at a time and not oftener than once or twice a minute, where the dog may eat them. Use scraps of food so small that 30 or 40 will not greatly reduce the animal's hunger. As soon as the dog eats each scrap readily and without delay, begin to pair the cricket with the food. Sound the cricket and then toss a piece of food. Wait half a minute or so and repeat. Sound the cricket suddenly, without any preparatory movements such as reaching for food.

At this stage your subject will probably show well-marked begging behavior. It may watch you intently, perhaps jump on you, and so on. You must break up this behavior, because it will interfere with other parts of the experiment. Never sound the cricket or give food when the dog is close to you or facing you. Wait until it turns away, then reinforce. Your conditioned reinforcer is working properly when your subject turns immediately and approaches the spot where it receives food. Test this several times. Wait until the dog is in a fairly unusual position, then sound the signal. Time spent in making sure the dog immediately approaches the food will later be saved manyfold.

Now, having established the noise as the reinforcer, you may begin teaching the dog. To get the feel of the technique start with some simple task, such as getting the dog to approach the handle on a low cupboard door and touch it with its nose. At first you reinforce any activity which would be part of the final completed act of approaching and touching the handle of the cupboard. The only permissible contact between you and the dog is *via* the cricket and the food. Do not touch the dog, talk to it, coax it, "draw its attention" or interfere in any other way with the experiment. If your subject just sits, you may have to begin by reinforcing any movement, however slight. As soon as the dog moves, sound the cricket and give food. Remember that your reaction time is important. Try to reinforce as nearly simultaneously with the movement as possible.

After your subject is moving freely about, reinforce any turn toward the cupboard. Almost immediately you will notice a change in its behavior. It will begin to face toward the cupboard most of the time. Then begin to reinforce only when the dog moves nearer the cupboard. (If you withhold reinforcement too long at this stage, you may lose the facing response. If so, go back and pick it up.) In a very short time — perhaps a minute or two — you should have the dog standing close to the cupboard. Now begin to pay attention to its head. Reinforce any movement that brings the nose close to the handle. You will have to make special efforts now to reduce the time between the movement and the reinforcement to the very minimum. Presently the dog will touch the handle with its nose, and after reinforcement it will repeat this behavior so long as it remains hungry.

Usually it takes no more than five minutes, even for a beginner, to teach a dog this behavior. Moreover, the dog does not have to be particularly smart to learn it; contrary to the usual view, all normal dogs will learn with about equal facility by this conditioning technique.

Before going on with other experiments test the effect of your conditioned reinforcer again two or three times. If the dog responds quickly and eats without delay you may safely continue. You should "extinguish" the response the dog has already learned, however, before teaching it another. Stop reinforcing the act of touching the cupboard handle until the dog abandons this activity.

As a second test, let us say, you want to teach the dog to lift its head in the air and turn around to the right. The general procedure is the same, but you may need some help in sharpening your observation of the behavior to be reinforced. As a guide to the height to which the dog's head is to be raised, sight some horizontal line on the wall across the room. Whenever the dog, in its random movements, lifts its head above this line, reinforce immediately. You will soon see the head rising above the line more and more frequently. Now raise your sights slightly and reinforce only when the dog's head rises above the new level. By a series of gradual steps you can get the dog to hold its head much higher than usual. After this you can begin to emphasize any turning movement in a clockwise direction while the head is high. Eventually the dog should execute a kind of dance step. If you use available food carefully, a single session should suffice for setting up this behavior.

Having tested your ability to produce these simple responses, you may feel confident enough to approach a more complex assignment. This time suppose you try working with a pigeon. Pigeons do not tame easily. You will probably want a cage to help control the bird, and for this you can rig up a large cardboard carton with a screen or lattice top and windows cut in the side for observing the bird. It is much less disturbing to the bird if you watch it from below its line of vision than if your peer at it from above. In general keep yourself out of the experimental situation as much as possible. You may still use a cricket as a conditioned reinforcer, and feed the bird by dropping a few grains of pigeon feed into a small dish through a hole in the wall. It may take several daily feedings to get the bird to eat readily and respond quickly to the cricket.

Your assignment is to teach the pigeon to identify the visual patterns on playing cards. To begin with, hang a single card on a nail on the wall of the cage a few inches above the floor so that the pigeon can easily peck it. After you have trained the bird to peck the card by reinforcing the movements that lead to that end, change the card and again reinforce the peck. If you shuffle the cards and present them at random, the pigeon will learn to peck any card offered.

Now begin to teach it to discriminate among the cards. Let us say you are using diamonds and clubs (excluding face cards and aces) and want the bird to select diamonds. Reinforce only when the card presented is a diamond, never when it is a club. Almost immediately the bird will begin to show a preference for diamonds. You can speed up its progress toward complete rejection of clubs by discontinuing the experiment for a moment (a mild form of punishment) whenever it pecks a club. A good conditioned punishment is simply to turn off the light or cover or remove the card. After half a minute replace the card or turn on the light and continue the experiment. Under these conditions the response which is positively reinforced with food remains part of the repertoire of the bird, while the response that leads to a blackout quickly disappears.

There is an amusing variation of this experiment by which you can make it appear that a pigeon can be taught to read. You simply use two printed cards bearing the words *peck* and *don't peck*, respectively. By reinforcing responses to peck and blacking out when the bird pecks *don't peck*, it is quite easy to train the bird to obey the commands on the cards.

The pigeon can also be taught the somewhat more "intellectual" performance of matching a sample object. Let us say the sample to be matched is a certain card. Fasten three cards to a board, with one above and the two others side by side just below it. The board is placed so that the bird can reach all the cards through windows cut in the side of the cage. After training the bird to peck a card of any kind impartially in all three positions, present the three chosen cards. The sample to be matched, say the three of diamonds, is at the top, and below it put a three of diamonds and a three of clubs. If the bird pecks the sample three of diamonds at the top, do nothing. If it pecks the matching three of diamonds below, reinforce it; if it pecks the three of clubs, black out. After each correct response and reinforcement, switch the positions of the two lower cards. The pigeon should soon match the sample each time. Conversely, it can also be taught to select the card that does not match the sample. It is important to reinforce correct choices immediately. Your own behavior must be letter-perfect if you are to expect perfection from your subject. The task can be made easier if the pigeon is conditioned to peck the sample card before you begin to train it to match the sample.

In a more elaborate variation of this experiment we have found it possible to make a pigeon choose among four words so that it appears to "name the suit" of the sample card. You prepare four cards about the size of small calling cards, each bearing in block letters the name of a suit: *spades*, *hearts*, *diamonds* and *clubs*. Fasten these side by side in a row and teach the pigeon to peck them by reinforcing in the usual way. Now arrange a sample playing card just above them. Cover the name cards and reinforce the pigeon a few times for pecking the sample. Now present, say, the three of diamonds as the sample. When the pigeon pecks it, immediately uncover the name cards. If the pigeon pecks *diamonds*, reinforce instantly. If it pecks a wrong name instead, black out for half a minute and then resume the experiment with the three of diamonds still in place and the name cards covered. After a correct choice, change the sample card to a different suit while the pigeon is eating. Always keep the names covered until the sample card has been pecked. Within a short time you should have the bird following the full sequence of pecking the sample and then the appropriate name card. As time passes the correct name will be pecked more and more frequently and, if you do not too often reinforce wrong responses or neglect to reinforce right ones, the pigeon should soon become letter-perfect.

A toy piano offers interesting possibilities for performances of a more artistic nature. Reinforce any movement of the pigeon that leads toward its pressing a key. Then, by using reinforcements and blackouts appropriately, narrow the response to a given key. Then build up a two-note sequence by reinforcing only when the sequence has been completed and by blacking out when any other combination of keys is struck. The two-note sequence will quickly emerge. Other notes may then be added. Pigeons, chickens, small dogs and cats have been taught in this way to play tunes of four or five notes. The situation soon becomes too complicated, however, for the casual experimenter. You will find it difficult to control the tempo, and the reinforcing contingencies become very complex. The limit of such an experiment is determined as much by the experimenter's skill as by that of the animal. In the laboratory we have been able to provide assistance to the experimenter by setting up complicated devices which always reinforce consistently and avoid exhaustion of the experimenter's patience.

The increased precision of the laboratory also makes it possible to guarantee performance up to the point of almost complete certainty. When relevant conditions have been controlled, the behavior of the organism is fully determined. Behavior may be sustained in full strength for many hours by utilizing different schedules of reinforcement. Some of these correspond to the contingencies established in industry in daily wages or in piece-work pay; others resemble the subtle but powerful contingencies of gambling devices, which are notorious for their ability to command sustained behavior.

The human baby is an excellent subject in experiments of the kind described here. You will not need to interfere with feeding schedules or create any other state of deprivation, because the human infant can be reinforced by very trivial environmental events; it does not need such a reward as food. Almost any "feed-back" from the environment is reinforcing if it is not too intense. A crumpled newspaper, a pan and a spoon, or any convenient noisemaker quickly generates appropriate behavior, often amusing in its violence. The baby's rattle is based upon this principle.

One reinforcer to which babies often respond is the flashing on and off of a table lamp. Select some arbitrary response — for example, lifting the hand. Whenever the baby lifts its hand, flash the light. In a short time a well-defined response will be generated. (Human babies are just as "smart" as dogs or pigeons in this respect.) Incidentally, the baby will enjoy the experiment.

The same principle is at work in the behavior of older children and adults. Important among human reinforcements are those aspects of the behavior of others, often very subtle, that we call "attention," "approval" and "affection." Behavior which is successful in achieving these reinforcements may come to dominate the repertoire of the individual.

All this may be easily used — and just as easily misused — in our relations with other people. To the reader who is anxious to advance to the human subject a word of caution is in order. Reinforcement is only one of the procedures through which we alter behavior. To use it, we must build up some degree of deprivation or at least permit a deprivation to prevail which it is within our power to reduce. We must embark upon a program in which we sometimes apply relevant reinforcement and sometimes withhold it. In doing this, we are quite likely to generate emotional effects. Unfortunately the science of behavior is not yet as successful in controlling emotion as it is in shaping practical behavior.

A scientific analysis can, however, bring about a better understanding of personal relations. We are almost always reinforcing the behavior of others, whether we mean to or not. A familiar problem is that of the child who seems to take an almost pathological delight in annoying its parents. In many cases this is the result of conditioning which is very similar to the animal training we have discussed. The attention, approval and affection that a mother gives a child are all extremely powerful reinforcements. Any behavior of the child that produces these consequences is likely to be strengthened. The mother may unwittingly promote the very behavior she does not want. For example, when she is busy she is likely not to respond to a call or request made in a quiet tone of voice. She may answer the child only when it raises its voice. The average intensity of the child's vocal behavior therefore moves up to another level — precisely as the head of the dog in our experiment was raised to a new height. Eventually the mother gets used to this level and again reinforces only louder instances. This vicious circle brings about louder and louder behavior. The child's voice may also vary in intonation, and any change in the direction of unpleasantness is more likely to get the attention of the mother and is therefore strengthened. One might even say that "annoying" behavior is just that behavior which is especially effective in arousing another person to action. The mother behaves, in fact, as if she had been given the assignment to teach the child to be annoying! The remedy in such a case is simply for the mother to make sure that she responds with attention and affection to most if not all the responses of the child which are of acceptable intensity and tone of voice and that she never reinforces the annoying forms of behavior.

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A Primary Social Science Law

CLARK L. HULL*

The establishment of a scientific law is one of the outstanding milestones in the development of a science. Such laws are established first for the simplest possible case, free from uncontrolled extraneous influences. Hull describes how the learning law of stimulus generalization was developed from studies in controlled laboratory situations, how evidence gradually accumulated to show that it was a broadly applicable law; and finally he examines anthropological data to support its pertinence in complex social structures. It is quite doubtful that the latter would have ever been suspected if it had not been for the former. Stimulus generalization means that modification of behavior is not an all-or-none affair, but rather that it follows a gradient along some continuum upon which the learned event falls. The student will appreciate this article more if he first reviews the material in his text on conditioning.

Clark Hull earned his PhD at the University of Wisconsin in 1918 and also taught there. For more than twenty years before his death he was research professor of psychology at the Institute of Human Relations at Yale. The fact that he is one of the most frequently cited psychologists of all time points up his great ingenuity and depth of research skill. His discussion of a primary law appeared in *Scientific Monthly* in October, 1950 (pp. 221–228), and is reprinted by permission of the publisher.

NOTE: Ten figures have been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the publisher's permission.

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* The author wishes to thank George P. Murdock for aid in preparing the material in the present manuscript which is concerned with cultural anthropology.

One hears much these days about the backwardness of the social sciences and the urgent need to hasten their development. In the opinion of many social scientists the hope for an early and useful development of these sciences depends upon three essential conditions: that all social phenomena occur according to invariable *primary* laws; that these primary social science laws are *quantitatively* determinable; and that they are statable by means of *true equations* of the type expressing the law of falling bodies.

This is to say, in short, that the social sciences are true natural sciences. Since this view of the nature of the social sciences is by no means universally accepted, a related sequence of concrete examples of a single law from this rich field will be presented as a kind of inductive demonstration of the general empirical soundness of the three conditions stated. Incidentally, the law we have selected for illustrative purposes will be seen to operate through a wide, and to some persons a surprising, range of phenomena, thus integrating into a single science facts which possibly may not have been previously thought of as being scientifically related.

The primary social science law in question is that of stimulus generalization (*5*, *6*). It is significant of the wide range of its operation that it was first investigated experimentally, and then formulated, by I. P. Pavlov, the great Russian physiologist. He diverted some of the salivary ducts in dogs through the outer skin and was thus able to measure the amount of saliva secreted. Using this quantitative methodology, Pavlov was able to report the preliminary observation of a social science or law:

> . . . if a tactile stimulation of a definite circumscribed area of skin is made into a conditioned stimulus, tactile stimulation of other skin areas will also elicit some conditioned reaction, *the effect diminishing with increasing distance of these areas from the one from which the conditioned reflex was originally established* (italics ours) (*11*).

Typical quantitative results of this sort were later published by G. V. Anrep (*1*). The point on the dog's skin (the stimulus continuum) conditioned to the salivary reaction was the flank and the various additional points tested for stimulus generalization included spots on the head, neck, shoulder, back, legs, and paws. A quantitative graphic representation of the outcome of the experiment showed that as the distance on the skin from the point of conditioning increased, the percentage of response decreased.

But how general is this supposed law? During the early days of the Institute of Human Relations, Bass and Hull (*2*) carried out an experiment to test the generality of the law, using the galvanic skin reaction on young men and thereby changing the type of reaction and the type of subject as well. The stimulus arrangement was essentially the same as for Pavlov's dog, with points being used on the shoulder, back, thigh, and calf. The outcome of this experiment was in practically exact agreement with Anrep's, in that the gradient is a falling one, as Pavlov had formulated. These results indicate that the law of stimulus generalization presumably operates in both dogs and humans, in the galvanic skin reaction and the salivary reaction. They therefore represent an appreciable degree of advance toward a behavioral integration.

Our next step in demonstrating the natural science nature of stimulus generalization is to show — in a preliminary way, it is true — that the galvanic skin reaction follows, in human subjects at least, a mathematical law as a function of the auditory pitch continuum. This experiment was performed by Carl I. Hovland (*4*) (Fig. 1). Because of Hovland's rather precise quantification of the scale separations in this experiment, it has been possible to fit what is believed to be a significant equation to his results. This is represented by the smooth curve running through the data

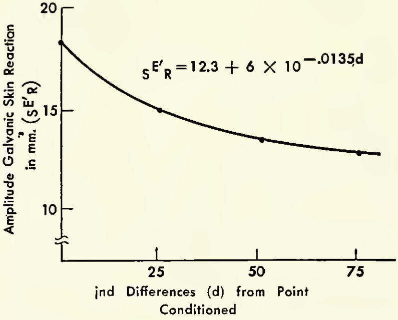

Fig. 1. Graph showing the four points determined by Hovland on his stimulus generalization gradient of the conditioned galvanic skin reaction with humans, based on pure tones tested at psychologically equal distances from the tone originally conditioned. The equation represents the curve fitted to the data points indicated by the dots. (Plotted from data published by Hovland *4*.)

points just below the statement of the equation shown in the figure. It will be noticed that the function does not fall to zero even if extrapolated, presumably because many of the stimuli to which the response is conditioned, such as the apparatus stimuli and those arising within the subject's body, remain constant, i.e., they do not change with the pitch of the pure tone which is deliberately changed (6). Stimulus generalization thus emerges as a natural science quantitative law, in this respect quite like the primitive law of falling bodies.

So far all the evidence presented on stimulus generalization has concerned the conditioned reflex. The next step is to consider whether the stimulus generalization law holds for ordinary habit formation. This problem was attacked by J. S. Brown (3). He trained groups of hungry albino rats to run down a straight alley toward a light at its end in order to obtain food. After this training had reached a fair degree of perfection, the rats were placed one at a time in a little harness made of rubber bands, and when they had reached the middle of the runway they were held back by a recording coil spring that indicated how strongly they would pull to get to the stimulus light, and so to the food at the end of the alley, the intensity of the test light often being varied widely and systematically from the trained intensity. Results indicated that the law of stimulus generalization operates here with a falling gradient, substantially as in the conditioned reflex. Thus, so far as this stimulus generalization law is concerned, the conditioned reflex in dogs and humans is integrated with ordinary habit in albino rats. As a result, one more very important integration is effected.

Proceeding further in our integrational investigation of the social or behavioral sciences, we meet the question of whether a law which operates in isolated organisms also operates in social science situations in the narrow sense, i.e., in situations where essentially more than one organism is involved. An elementary case in point is found where one organism becomes a critical stimulus for the behavior of another. Neal E. Miller and John Dollard (8) carried out a decisive yet simple experiment on this point, using two groups of hungry albino rats. For convenience we shall call the first group "stimulus" animals, and the second group "response" animals. Miller and Dollard first trained the stimulus rats to run up the stem of the elevated T-maze, to cross the gap to the right or left, and then to go to a black or white card placed at one or the other arm of the T by chance arrangement, where a bit of commercial dog food was found and eaten. Naïve response rats of the same type were then placed on the maze, but behind the trained stimulus animals. Half of the new response animals were easily trained to turn in the *same* direction as the stimulus animals, and half were trained to turn in the *opposite* direction from that taken by the stimulus animals. At a point . . . about midway up each arm toward the card, the response animals received dog-food reward when they had taken the correct path.

After twelve days of training, seven trials per day, the animals of the response group as a whole took the same turn as the stimulus animals (cards being absent) on 84 per cent of the fifty-six trials, whereas the "contra" group of the response animals took the same turn as the stimulus group only 15 per cent of the fifty-six trials, pure chance of course yielding 50 per cent. The difference between 84 and 15 is 69, which we shall take as an index of the composite strength of the two tendencies to respond to the behavior of the stimulus animals.

At this point Miller and Dollard ingeniously introduced into this social situation a test for the law of stimulus generalization, by using black instead of white stimulus animals, a marked difference on the stimulus continuum. The index value in this case was approximately 40. Quite as one would expect, there was still a distinct tendency to respond to the stimulus animals, even though they were black. The index of the turning tendency, moreover, has clearly fallen, according to the stimulus generalization law of Pavlov and the other investigators whose work we have considered. No doubt if a gray rat had been used as a stimulus animal, an index value a little less than the mean of the present values would have been secured. Once more we observe an extension of the scientific integration demonstrated by a common natural science law to include the responses of one organism to the stimulus presented by the behavior of another organism, i.e., to include *social* behavior in a very elementary form, probably allied to the extremely important phenomenon of imitation.

Social behavior ordinarily involves more than merely responding to another organism as a stimulus. For one thing, it frequently involves the *mutual* stimulation of at least two organisms, and mutual responses to those stimulations, the acts sometimes being directed to the body of the other organism. Miller (7) also investigated this more intimate type of social situation at a simple level once again with albino rats. He placed these animals together by pairs on a charged electric grid and, when by chance they approached each other, he reinforced this act by terminating the shock. Later he did not turn off the shock until the rats moved their paws more or less as in fighting. Finally the rats of the entire group would strike each other vigorously, as in ordinary rat-fighting, at once after the shock was turned on.

The operation of the law of stimulus generalization in this social interaction situation was demonstrated as follows. After the original training had taken place, two rats were put on the grid with a celluloid doll, the visual appearance of a rat and that of the doll being well separated on the stimulus generalization continuum. In such cases, eleven out of twelve trained animals began striking each other as soon as the shock was turned on; only one animal struck the doll and this animal did so briefly, at once turning to strike the second animal. But when placed on the grid with the doll alone, six out of the twelve animals knocked the doll over by striking it with the paws, whereas the remaining six upset the doll by chance running against it. Twelve control animals not trained to strike another rat when shocked were put on the grid with the doll, one at a time. Only one struck at the doll, whereas the other eleven rats upset the doll by chance running against it. Miller concludes from these results that the trained attack behavior generalized from the other animal as a stimulus object to the doll was much weaker than from one stimulus animal to another. This is, of course, exactly in line with the law of stimulus generalization, including its falling gradient as seen in the preceding examples. Miller believes with reason that this experiment represents the substance of the human psychoanalytic phenomenon of displacement (7). Thus the law of stimulus generalization is seen also to be operating in an elementary interactive social situation, which constitutes an additional integration of individual behavior to social behavior of a very special sort.

The law of stimulus generalization is known to apply to both the free motor and the symbolic social behavior of human beings, although no simple quantitative demonstration has come to hand. Young children notoriously generalize the response of calling the father "daddy" by applying the term to other men. They are apt to call the first rabbit they see a "kitty," and the first horse a "cow," and so on. Clinical evidence of stimulus generalization is also abundant. Both psychoanalysts and psychiatrists, for example, recognize that adult males in our own society characteristically react toward a boss or other person in an authoritative position with types of behavior acquired in childhood and adolescence toward the individual's own father.

With this observational transition we move forward into the field of cultural anthropology. Leading anthropologists assume that the "cultures," or bodies of custom, of human societies represent adaptive responses learned by collectivities of individuals over time. These cultures should, therefore, reflect all the factors involved in individual learning, including the phenomenon of stimulus generalization, and this should be susceptible of quantitative demonstration through comparative studies of cultural materials. We shall select one of a considerable number of examples given by George P. Murdock (9) with respect to the linguistic terms applied by different societies to various types of relatives as these relate to the cultural rules governing where a man and wife reside after marriage.

The four most common rules of residence are: *neolocal*, where, as with ourselves, a couple normally establishes a new household separate from the homes of the parents of both; *patrilocal*, where they live with or near the husband's parents; *matrilocal*, where they live with or near the wife's parents; and *bilocal*, where they live either patrilocally or matrilocally, depending upon economic or prestige factors. Murdock's evidence shows that there is a tendency for the term meaning "mother" in any language to be extended to aunts who normally live with or near the mother under the prevailing rule of residence. This is rarely the case with either neolocal or patrilocal residence. Under matrilocal residence, however, the maternal aunt resides in the same household as the mother or in a dwelling close by, and under the bilocal residence both paternal and maternal aunts are likely to be spatially associated with the mother; under these conditions the term "mother" tends to be applied to aunts.

Any aunt who resides with or near the mother is likely to assist the latter in caring for, playing with, disciplining, and even nursing her children, and thus to a considerable extent she plays the role of a secondary mother. Under bilocal residence, a growing child comes to regard both paternal and maternal aunts as people who resemble and act like his mother, and this condition prevails even after marriage if he remains at home.

Here enters the principle of stimulus generalization. The term used for "mother" is here regarded as a response. This response will naturally generalize to other relatives as a function of the similarity of the stimuli associated with them in relation to the stimuli provided by the individual's own mother. In all cultures there are some similarities; aunts as well as mothers, for example, are females. Where bilocal residence obtains, the stimulus similarities between aunts of either type and the actual mother approach identity, in contrast to other rules of residence, and this constitutes the basis in the stimulus continuum for the generalization gradient. Thus people should tend to call both paternal and maternal aunts "mother" more strongly in cultures having bilocal residence than in those following other rules.

It must be observed here that the concrete manifestations of the stimulus generalization gradient in the situations considered previously are strikingly different from those found in this and certain other situations. The graphs for the studies described above show that as the stimulus continuum becomes increasingly different from the point of origin, the response being generalized becomes weaker and weaker, nothing in particular taking its place (see Fig. 1). But in a situation where there is a definite competition between two responses of the all-or-nothing variety, such as the custom of calling the aunt "mother" or some other name, a distinctly new element enters, namely, that of chance. Moreover, the probability of the respective responses in a given culture will depend not only upon the strength of the one being generalized, but also upon the strength of the other or competing response tendency, together with large numbers of smaller but unknown factors. This means that a problem of this kind cannot be solved by observing a single culture, but must be based on a very large number of cultures. By the pooling of many cultures the influence of irrelevant factors tends to be equalized. It also means that when this large number of cultural data is assembled it will make up a fourfold, or tetrachoric, correlation table or surface.

It happens that for years anthropologists have been patiently studying the ways of great numbers of primitive peoples and publishing their findings. Recently the Yale Institute of Human Relations has been collecting and assembling these widely scattered studies systematically. This is a research project which was initiated by Murdock and known as the Cross Cultural Survey. (This project is now known as the Human Relations Files, Inc., and is directed by C. S. Ford.) A tiny sample is shown in Table 1. The coefficient of association (Q) used by Murdock is a simple one, depending primarily upon the fact that in a positive relationship the product of items $a \times d > b \times c$. For example, in Table 1, $a \times d = 1{,}683$, whereas $b \times c = 363$, which indicates that there is a definite tendency for bilocal residence to be differentially associated in cultures having the tendency to call the aunts "mother." In order to convert the tendency into a quantitative index ranging from zero to 1.00, the following simple formula is used:

$$Q = \frac{(a \times d) - (b \times c)}{(a \times d) + (b \times c)}$$

Substituting in this formula, we have

$$Q = \frac{1{,}683 - 363}{1{,}683 + 363} = \frac{1{,}320}{2{,}046} = +.645$$

Appropriate computations show that the value so obtained would be secured by chance only once in about one hundred times (9).

It is evident from the preceding considerations that the principle of stimulus generalization will apply in analogous verbal responses as well as in the ones just considered. There will necessarily

TABLE 1. The Number of Cultures Calling the Maternal and Paternal Aunts "Mother," and Those not Doing So, as a Function of Whether the Custom of Bilocal Residence Is in Operation (Adapted from Murdock [9, p. 152])

Bilocal Residence Customs		Other Residence Customs	
Aunts called "Mother" (a)	Aunts not called "Mother" (b)	Aunts called "Mother" (c)	Aunts not called "Mother" (d)
9	11	33	187

be female siblings called "sister." There will also be female cousins who not only are surrounded with the same inanimate environment as the actual sister but who, under bilocal residence, live with and behave toward the subject much as sisters do. As a matter of fact, the tendency to call both the mother's brother's daughters and the mother's sister's daughters "sister" yields a coefficient of association of +.73. In an analogous situation the tendency to call both the father's sister's daughters and the father's brother's daughters "sister" yields a Q of + .75. Both these values would occur by chance only about once in a thousand times. By a similar analysis, we should expect a stimulus generalization of the response of calling one's own child "daughter" to extend to the daughter of one's sister and of one's brother in cultures having bilocal residence. As a matter of fact, the tables secured from Murdock's 250 cultures at present represented in his survey yield a Q of +.73, again with a mere chance occurrence of only about one in a thousand (9).

Glancing back over our examples of the operation of the law of stimulus generalization, we find this principle manifesting itself in the conditioned-reflex salivary secretion of dogs to touches on the skin, in the conditioned-reflex galvanic reaction of men to touches on the skin, in ordinary learned behavior of rats to different light intensities, in the locomotor behavior of rats to the social stimulus of such behavior in other rats, in the interactive fighting behavior of rats, and, finally, in the familial speech reactions of primitive people to relatives, depending on varying residence practices. It is believed that these varied phenomena are demonstrated to be in the same science, just as the various phenomena manifesting the law of gravity are demonstrated to be in physical science. Upon what, except the laws of a given science, depends its essential unity? Whether this science (or these sciences as a group) shall be called "social" or behavioral, or whether a quite new name shall be coined, as Murdock has suggested (*10*), is quite irrelevant to science as such. The urgent question is that the science be developed as rapidly as possible.

Someone has said that social or behavioral sciences are now at about the same stage of development that physics was when Galileo began his quantitative investigation of the elementary laws of motion. There is evidently some truth in this statement. On this analogy it would seem that if a relatively small amount of effort should be concentrated on the task of searching for and verifying the elementary behavioral laws involved, the social sciences would soon be on their way to the type of development which began in physics with Galileo's productive life. This view is strongly supported by our experience at the Institute of Human Relations at Yale, where much of the work yielding the phenomena described above was performed. However, we must avoid the besetting weakness of Americans to be largely diverted from the pure-science search for primary laws to searches for short-sighted, immediate rule-of-thumb solutions to practical problems.

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18

What Is Memory?

RALPH W. GERARD

Memory plays a fundamental role in learning, since one could scarcely improve from time to time on a task unless he retained something of the previous attempt. Here a neurophysiologist describes his efforts to study experimentally the nature of memory and its biological mechanisms. He has shown, along with others, that the time factor is critical in remembering, and this fact has implications for a neurology of memory. For the most part, however, we know very little about the participation of the brain in remembering. Gerard believes that we will eventually establish that there are "enduring static traces" or physical changes in nerve tissue. Furthermore, he suggests a number of exciting hypotheses for experimentation. Not all psychologists will agree that it is appropriate to look inside the head for memory deposits, but most of them would applaud efforts to increase our understanding of the response mechanisms utilized in memory acts.

Dr. Gerard is Director of the Neuropsychiatric Institute of the University of Illinois College of Medicine. He holds both the PhD and MD degrees, and has been interested in psychobiological problems for a number of years. Dr. Gerard's article appeared in *Scientific American* in September, 1953 (pp. 118–125), and is reprinted with permission of the publisher.

A textbook of biochemistry widely used early in this century had a famous passage on the memory of linseed oil. Exposure to light makes the oil turn gummy. A brief exposure may not cause any observable change. But on later illumination the oil will change more rapidly than if it had not already been exposed. The oil "remembers" its past experience and behaves differently because of it. Its memory consists in the fact that light produces, among other things, substances which aid the light-induced oxidations that make it gummy.

However far removed this may be from remembering the Gettysburg address, it clearly points up one way in which memory can work — by means of material traces of the past — and the difficulty of defining what memory is. Actually the behavior of the oil and of a human being memorizing the Gettysburg address are but extremes of a spectrum of such behavior in nature. Between these extremes there is a pretty smooth continuity, and any concept which defines memory much more narrowly than "the modification of behavior by experience" will run into trouble. Consciousness, for example, is not necessary to memory, for men remember, and recall under hypnosis, innumerable details never consciously perceived.

Where, then, shall we draw the line? A pebble, rubbed smooth in a stream, rolls differently from the original angular stone. Experience has here modified behavior; the past has been stored in a changed structure. Yet this does not greatly interest us as an instance of memory. Perhaps we should restrict the notion of memory to changes in systems which participate actively in causing the change. Then linseed oil "remembers," and so does the bulging calf muscle of a ballet dancer. Does a developing embryo "remember" the major steps, and missteps, in the long evolution of the species? Do trees "remember" good and bad seasons in the thickness of their rings? Is a film a memory of light in chemicals and a tape recording a memory of sound in magnetism? Is a library a memory of thoughts in books and a brain a memory of thoughts in protoplasm? Even to identify memory, let alone explain it, is no simple matter.

Without memory the past would vanish; intelligence, often called the ability to learn by experience, would be absent, and life would indeed be "a tale told by an idiot, full of sound and fury, signifying nothing." Today the search for the fundamental mechanisms of memory in the nervous system is being pressed with hopeful enthusiasm. The smell of success is in the air and great developments seem to wait just over the next ridge.

Let us consider as memory only that exhibited in man and in such sophisticated behavior as is usually close to conscious awareness. One great problem is: Why do certain impressions become conscious upon reception while others do not; why does awareness accompany some acts, not others; what, in general, invests certain neural events with a phosphorescence of subjective recognition? This question remains unanswered, but the answer is likely to come in terms of the evolution of awareness of certain types of neural events as useful to the organism.

Memory involves the making of an impression by an experience, the retention of some record of this impression and the re-entry of this record into consciousness (or behavior) as recall and recognition. The initial impression need not have entered awareness in order to be retained and recalled. Anyone asked to recall what he has just seen in a room or in a picture does a less complete job than a subject under hypnosis even years later. I have been told of a bricklayer who, under hypnosis, described correctly every bump and grain on the top surface of a brick he had laid in a wall 20 years before!

Guesses have been made as to how many items might be accumulated in memory over a lifetime. Some tests of perception suggest that each tenth of a second is a single "frame" of experience for the human brain. In that tenth of a second it can receive perhaps a thousand units of information, called bits. In 70 years, not allowing for any reception during sleep, some 15 trillion bits might pour into the brain and perhaps be stored there. Since this number is more than 1,000 times larger than the total of nerve cells, the problem of storage is not exactly simple.

Whether or not all incoming sensations are preserved as potential memories, there is an important time factor in their fixation. Youthful, repeated or vivid experiences seem most firmly fixed. They are the last to survive disrupting conditions — old age, brain damage, concussion or mental shock — and the first to return after a period of amnesia. A goose seems to fix upon the first moving object it sees as its mother and thereafter follows it about. An infant, suddenly frightened by a barking dog, may fear dogs for the rest of its life.

More often experiences force themselves into attention and memory only gradually. Even learning to perceive is a long, troublesome matter. Adults gaining vision for the first time must labor for months to learn to recognize a circle and to distinguish it from a triangle, let alone to see letters and words.

After any experience, apparently considerable time must elapse between the arrival of the incoming nerve impulses and the fixing of the trace. If a photographic plate acted similarly, it could not be developed at once after exposure but only some time later. Recent experiments in our laboratory have emphasized this phenomenon. Hamsters daily were run in a maze and were given an electric shock afterward. When the shock was given four hours or more after the run, it did not influence the learning curve. (The question of cumulative damage is irrelevant here.) A shock one hour after the run impaired learning a little, and as the shock was brought closer it interfered more and more, until at one minute after the run, it destroyed learning completely. Clearly some process of fixing continues for at least an hour.

The nature of the fixing process must be left for the moment, while some related phenomena of memory are noted. One is a type of erasing. A memory wizard who can glance through a newspaper and then name the word at any position in any column on any page makes an effort to forget this mass of information at the close of a performance so as not to "clutter up" his memory. Perhaps similar is the removal by a presuggested signal of an instruction to a hypnotized subject to perform some act after arousal. In such instances stored experience traces seem to be expunged, but whether they are really irrecoverable is perhaps not fully established. Recall alone may be at fault, as in simple forgetting.

A second phenomenon has to do with the alteration of memory traces. The memory left by an experience can change progressively. Memory, as has been well said, is reconstructive rather than reduplicative. It is also highly associative. Pictures redrawn from memory at intervals become more regular (details are smoothed out) or more exaggerated (some salient feature is caricatured) or an object different from the original (a chair looks more like a horse after each redrawing).

Besides fixation and storage, there remain recall and recognition. Failure to recall does not imply loss of the trace: witness the frequent experience of temporary inability to say a familiar name "just on the tip of my tongue." The most intriguing problem about memory, however, is not the existence but the tremendous specificity of recall. Both in its positive and negative aspects — as seen in dreams, in amnesia, in suppression and repression, in hypnosis, in hysteria and dual personality — recall offers bizarre phenomena, formidable to explain.

One day not long ago, as I left a lecture room I caught a fleeting glimpse of the head and shoulders of a person half-silhouetted against a window over a hundred feet away. I knew at once with certainty the name of the person standing there, although he had not crossed my path nor his name my mind for more than 15 years. A chord, a note, a word, a line can recall a long past experience. Or it may reawaken an intense emotion without the connected experience; I know of a young man who invariably faints at the sight of a stethoscope, yet has no general fear of doctors or illness and no idea of why he reacts so uncontrollably.

Recall may sometimes be disguised, seemingly to protect the subject from the anguish of fear or shame or pain. Parts of a story that touch upon a personal problem are often "forgotten" only to appear, modified, in a dream. A man who was unable to recall the telephone number of a girl friend while visiting her city dreamed of red objects that night and recognized in the morning that the numerical position of the letters *r*, *e*, *d* in the alphabet gave the missing number. This opens the door to the whole edifice of symbols. An unsophisticated youngster, directed under hypnosis to dream about bed-wetting, may report his dream in Freudian symbols which only an experienced psychoanalyst — or another naïve youngster under hypnosis! — can recognize as referring to bed-wetting.

Finally, what of the compulsive neurotic whose affliction is banished when some infant experience is dredged up during psychotherapy? What of the psychoneurotic soldier, unable to recall a battle beyond a certain point, who relives under pentothal all the horror of seeing a companion's head blown off and is then able to remember and talk about it? What of aphasics, who can recognize words by sight or by sound but not both? And what of dream experiences, not actually sensed but presumably due to intrinsic brain activity, which may be recalled in wakefulness or only in other dreams, if at all? The problem of recall and its specificity is the real challenge to neurophysiology.

The human brain is composed of some 10 billion nerve cells, more or less alike, which interact in various ways. Each cell contributes to behavior, and presumably to mental activity, by firing impulses or failing to fire. All the phenomena of memory must be explained in terms of the temporal and spatial patterns of these discharges.

If experience is to modify behavior, the activity of neurons connected with an experience must alter their subsequent activity patterns. Two general questions regarding the neural trace must be asked, and both can be given a reasonable, if not a certain, answer today. The first is: Does memory depend on a continuing activity or on some static residue, some structural alteration, left behind by past activity? Is a river the water flowing in it or the channel the water cuts? The answer today is tending strongly toward the latter. The second question is: Is the structural trace (or dynamic process) for each memory located in a particular region, or are memory traces suffused through the brain in some way? Are memories marks placed on violin strings or are they wave trains playing over these strings? The latter would imply dynamic memory, but the trace could still be structural, like the wiggled groove on a phonograph record. Whether the trace is localized or diffuse, its exact nature is a third, if somewhat subsidiary question. Current investigations suggest that there are multiple patterns of local traces rather than a single well-localized one, but the nature of the trace is almost pure guess.

A dynamic memory would depend on the continuous passage of nerve impulses or on the maintenance of some active metabolic or potential change in neurons, presumably reinforced by the repeated arrival of impulses. A nerve impulse traveling around a closed loop of connecting neurons would be a mechanism for such a dynamic memory, each remembered item depending on the activity of a particular loop or net of neurons. (Actually, since there are more memories than neurons, different memories would have to share portions of path, but this is physiologically possible without snarling traffic.) Such a memory device would, however, be metabolically expensive, and if the impulses really left no long-enduring trace, memories would be completely and irrevocably lost once the activity stopped.

There is a simple way to test the question as to whether a memory is purely dynamic. One need only stop all nerve impulses in the brain momentarily and observe whether a memory is lost. The problem, of course, is to stop the impulses reversibly. In sleep or under anesthesia the brain slows down but remains electrically active, and memories are largely undisturbed. But the brain's electrical activity can be stopped in several ways. When a hibernating animal, such as the hamster, is cooled to a body temperature of 40 degrees Fahrenheit, needles thrust into its brain fail to pick up electrical activity; it seems reasonably certain that the reverberating impulses are frozen in their tracks.

Another way of stopping the circulating nerve messages is to stimulate the neurons simultaneously by a vigorous electric shock, so that all the neurons presumably are unable to respond to a normal impulse. Such a shock does produce a period of complete electrical silence, measured in seconds or minutes. If the lower brain, controlling respiration, is included, the normal messages for breathing are suspended. Brain neurons may also be made electrically inactive by withholding oxygen for some two minutes or by withholding sugar. In all these cases the animals recover rapidly after the temporary treatment, and their memory can be investigated.

The experiment is now straightforward. Hamsters are first taught a simple maze. They are then hibernated or given electric shock or made to breathe nitrogen for a few minutes. After recovering, they are tested for their retention of learning. If they remember the way through the maze, the memory did not depend upon reverberating circuits or upon any other purely dynamic process. They remember!

This by no means excludes the initial dependence of memory on neuron activity. The passage of impulses is necessarily involved in the initial experience that leaves a memory trace. The fact that repetition makes for better memory reminds us of the analogy of the river cutting a channel in its bed. Indeed, the reason it takes time to fix a memory trace in the brain may be that impulses must circulate over their selected pathways many times in order to leave behind an enduring material change.

What, then, is this enduring static trace? Muscle fibers react to continued exercise by increasing their content of hemoglobin-like pigment; the meat becomes darker. No one has described an enduring chemical change in nerve or brain as a result of activity, but it must be conceded that this is a difficult quest and has not been undertaken very seriously. Muscle fibers swell and become hypertrophied on exercise. It has been shown recently that nerve fibers also swell slightly as they conduct impulses, and the swelling persists at least for minutes and hours if not for days and years. Nerve fibers also show alterations in potential which outlast the active period by many minutes. Any of these changes might occur at the critical junction between one neuron and the next — the synapse or gap across which conduction is considerably more precarious than it is along the uniform nerve fiber. The change might then make the passage of subsequent impulses easier or more difficult.

Certain it is that activity can facilitate and inactivity hinder the subsequent passage of an impulse across a synapse. This has been learned from experiments on simple spinal cord reflexes involving only one sensory neuron in each arc. If some of the sensory nerve fibers serving the knee-jerk reflex are stimulated, say a hundred times a second for 10 minutes, and are then tested with a single stimulus, the number of motor fibers responding (in effect, the size of the knee-jerk) is increased tenfold above the normal response to a single shock. The increased responsiveness dies out in two or three phases, one lasting for seconds and one certainly for hours. This suggests that the local trace left behind may have involved several changes. Conversely, when impulses are prevented from reaching the synapses of this reflex for days or weeks, by cutting the sensory nerve connections, the reflex elicited by a single shock is strikingly below normal. After a few shocks, however, the response begins to improve, and again the return toward normal seems to involve more than one phase.

Many suggestions have been made as to what kinds of changes may alter the response at a synapse. They must be structural — either in the fibers and contacts or at the molecular level, where displacement of ions might alter the electric potential or displacement of atoms change the chemistry. One observed change, already noted, is the swelling of fiber end-bulbs induced by activity. The swelling should favor the transmission of impulses. Actually this explanation is a modern version of one of the earliest theories of memory: that activity somehow causes a nerve fiber to sprout new twigs near its termination and so to increase its effective contact. Neurons from brains of older persons have in fact been reported to branch more extensively than those from the young, and the notoriously poor memory of old people for recent events might be attributed to the neurons' inability to grow more twigs or to accommodate more connections. A closely related suggestion, that electric-shock treatment of some psychoses is successful because it destroys certain existing connections and permits neurons to make "healthier" ones, is based upon the observation, made on transparent tadpole tails, that electric shocks cause nerve filaments to be torn off.

Another mechanism enjoying some current popularity is chemical. Since every type of cell of every individual of every species has its own chemical personality, and since this differentiation of cells depends on proteins, the specificity of memory might be due to changes in nerve proteins. Each trace could be limited to one or a few molecules in an end-bulb of a neuron. The body cells that manufacture and release antibodies against invading organisms "learn," as we know, from experience. When typhoid proteins, for instance, enter the body the first time, antibodies are produced slowly and in small amounts. But years later, when almost no antibody remains in the blood, a new invasion by this specific protein is met by a prompt and vigorous release of antibody that nips the disease before it gets started.

It is far from explained just how the passage of nerve impulses would alter protein molecules at a synapse, or how, in turn, an altered protein composition would aid or hinder the passage of a nerve impulse. Yet some such chemical mechanism cannot be discarded, for nerves and synapses can be highly specific and can change their specificity. For example, if an extra muscle is transplanted into the back of a salamander, the nerve to which it becomes attached will make the transplanted muscle contract simultaneously with the normal flexor if the transplant is a flexor muscle or with the normal extensor if it is an extensor. Somehow the central synapses have "discovered" what kind of muscle is attached at the far end of the motor neuron and they let through nerve impulses at the proper time for a muscle of this sort.

The essence of all these suggested mechanisms is that a given end-bulb of a neuron, initially ineffective, can become and remain effective as a result of activity. Indeed, mathematical theories of the behavior of complex nerve nets demand only such an assumption to account for the basic properties of memory. Moreover, the total number of end-bulbs on the neurons of the brain, some 10 trillion, about matches the number of bits of information the brain may store during a lifetime. But then each memory would have to have its exact microscopic spot in the brain, would have to stay put through life, and would somehow have to be deposited, once and once only, at a given end-bulb, despite the wide sweep of impulses through the brain during each experience. This raises sharply the problem of localization.

The degree of localization is probably the key problem of memory. If we could expect to find a given memory at a given place in the brain, our experimental problem would be comparatively simple. We would locate the region and compare structural, chemical or physical changes there in animals with and without the appropriate experience. Some years ago there was an exciting report that electrical stimulation of a small spot in the cerebral cortex caused trained dogs to make a conditioned leg movement, while in unconditioned or deconditioned animals the same region was inactive. Alas, this claim has not been substantiated. There is, however, valid evidence of a kind of memory localization. When the exposed brain of a person under local anesthesia for a brain operation is stimulated electrically, various conscious effects are produced. Stimulating the occipital lobe, which receives the sensory fibers from the eyes, gives visual sensations. Similarly, stimulation of other specific regions produces sounds and skin sensations. These responses are not related to specific past experiences. However, other regions of the brain, particularly the temporal lobe, do respond to stimulation with the conscious recall of quite specific events from an individual's past.

The particularity, however, is at best only roughly localized, and localization largely vanishes when we look at the effects of brain damage. Large sections of nearly any part of the brain can be destroyed without loss of particular memories, or indeed, without disturbance of the memory function. Human brains have been extensively damaged by trauma, by tumors or abscesses, by loss of circulation, by operative removal, or by the shriveling away of extreme age. In these cases the ability to learn new things, to make sound judgments, to see new relations and to imagine new ideas may be profoundly disturbed, but the recollection of past experience is likely to remain reasonably intact. The frontal lobes of mental patients would not be amputated so freely as they are today if any serious defect in memory resulted.

So we are left with good reasons for believing that memories depend on static changes left behind by the passage of nerve impulses; that these changes occur somewhere along the paths of the impulses traveled and are most likely at particular synapses; that the traces are to some extent gathered in certain regions, but that extensive brain damage is not accompanied by comparable losses of memories. One line of escape from the dilemma is to assume, as we can quite reasonably, that a given memory is not represented by one specific local change but by a pattern of many changed loci — a pattern with sufficient redundancy so that if part of it is destroyed the rest will still suffice to represent the memory.

Such a view raises serious difficulties, but they do not appear to be insurmountable. For example, if thousands of neuron endings are involved in one memory, how can the brain store the huge number of memories we have assumed? Actually such indirect coding could greatly increase its storage capacity. Ten letters, each used to represent one item, give 10 items; but 10 letters used in groups as words give a vast number of items. Such patterned memory traces might also actually change with time, as particular neurons or synapses dropped out of the ensemble, and so permit the alteration of memories observed on successive recalls.

We come finally to the problem of recall. Recall is a matter of attention, a selecting or rejecting of particular memory traces. Here enter all the intriguing phenomena of specificity, suppression, symbolization and the like. The physiological explanation of these is certainly not yet at hand. Perhaps the best clue now available is the control of cortical activity and of conscious awareness by nerve centers in the older and deeper parts of the nervous system. Much recent experimentation has shown that these primitive jumbled masses of nerve cells in the upper part of the brain stem exercise a profound influence on the more recently evolved neurons of the cerebral cortex. Impulses from these deep cell groups continuously spray out to the cortex to regulate its activity. An excess of stimulation leads to cortical overactivity and convulsive seizures, followed by the unconsciousness of exhausted neurons. When the impulses are few and the cortex is comparatively inactive, the brain waves slow down and normal sleep results. One is tempted by the picture of an electron beam scanning the tube face of a television camera, picking up impressions left by the outside world from one tiny region after another. But whether such beams of nerve impulses, playing upon the cortex, do actually control attention, whether they are responsible for the evocation of specific memory traces, only the future can decide.

We are beginning to have some reasonable guesses as to the "gadgets" that would serve as a memory mechanism — guesses sufficiently concrete to permit testing by rigorous experimentation. I think it is realistic to hope for an understanding of memory precise enough to permit experimental modification of it in men.

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Memory Systems in the Brain

J. Z. YOUNG

Psychological techniques have proven to be powerful tools in the hands of other scientists, as shown in this report from a British biologist. One should not assume from his opening remarks that psychologists are not interested in the mechanisms of the body — rather it is on such problems that psychologists and physiologists have formed profitable partnerships. Dr. Young shows the fascination with model building which is so popular with British scientists, and is coming to be more widely used in the United States. Although a model of a theoretical brain function can not verify the theory, it can direct the way of inquiry, since if the model fails the theory is suspect. The author's emphasis upon brain involvement in memory (here studied in an interesting though unusual laboratory animal) would be considered by some psychologists as constructs beyond the facts and relationships actually observed. They are nevertheless interesting as guides for future research.

Professor Young is a member of the faculty in the Department of Anatomy, University College London. The article which follows was originally presented as a talk on the BBC Third Programme, and was published in *The Listener* of December 1, 1955 (pp. 929–931). It is reprinted by permission of the author and the publisher.

We should all of us like to know what changes go on in our heads when we learn and when we forget, so that we can control these processes more effectively. Such problems can be approached in various ways: for example, psychologists and educationists study the conditions that accelerate or retard learning and forgetting. The biologist can try to use a more direct approach; namely, to find out what are the characteristic features of those parts of the brain that are capable of learning. Then he may hope to go on to study the actual changes in the tissues as the brain builds up its memories.

UNDERSTANDING THE INTERNAL WORKINGS

It must be admitted at once that little progress has been made along these lines. Nevertheless I believe that ultimately it will prove to be a more profitable approach than that of a psychologist who studies the organism only from outside. Most of our progress in dealing with the functioning of various parts of the body has depended on finding out how they work. We go to a doctor when our stomach or liver is disordered because we believe he knows 'how it works' and what is wrong with it. That is to say, we expect him to understand its actions just as we would expect an engineer to understand a motorcar. I do not propose to deal here with the question of the limitations of such a mechanistic approach to biological problems. I merely note that most of us have a strong belief that a person who understands the internal workings of any part of the body or any machine is likely to be able to control it better than someone who nas only looked at the outside.

The problem in the case of the memory systems of the brain is to know where to begin. Nervous systems are so immensely complicated and the things that they do and remember are so intricate that it seems impossible that we shall ever understand them. One of the means that biologists use when faced with a complicated process is to find an animal in which conditions are relatively simple. This was one of the reasons that led my colleague, Mr. Boycott, and me to study the memory systems in octopuses. Actually, as we shall see, they are capable of remembering quite complicated things. Nevertheless, study of the parts of the brain with which they do it has given valuable hints about the way memories are carried in our own brains.

One of the great difficulties in any experiments on memory is that the animals one deals with are not likely all to behave alike. By definition, animals with good memory systems will differ because of their varied early experiences. We find this to be true of the octopus. Some are much quicker at learning a given habit than others. Ideally, one should be able to trace the progress of an individual from birth onwards, but in practice this would be difficult. After octopuses have hatched they spend the first part of their lives swimming near the surface of the sea and their behavior at this stage has never been studied. When we get them into the laboratory we put them each in a single tank, with a few bricks at one end, among which the octopus makes its home. We can then make tests by showing various objects at the other end of the tank and noting whether the animal comes out to attack them. If crabs are shown the octopus will probably not come out for a day or two and then will gradually begin to do so. The first attacks are made only after the crab has been in the tank for a minute or more and the octopus comes out cautiously. Then, with further trials, he will attack faster and faster, and finally take the crab within one or two seconds of its appearance.

There is reason to think that in the sea octopuses often eat crabs. An octopus may occupy a given cranny among the rocks for a considerable time. Outside this home there are often found the shells of the animals that it has been eating. These, like the kitchen middens of primitive peoples, tell us about the diet. Remains of crabs are often found in the heaps, but there may also be the shells of bivalves and other animals that the octopus has eaten. So we cannot tell what may have been the diet of any particular octopus, though it is likely to have included crabs.

In order to study the learning capacity further, we have tested the animals by showing them figures made of metal or plastic and of shapes that the octopus is unlikely to have seen before, such as circles, squares, or rectangles. Moreover, we have controlled the factor of hunger by feeding the octopus regularly, though not abundantly, for several days by putting pieces of fish in its home. When an octopus has become thoroughly domesticated in this way in its tank one can then introduce, say, a small white square at the end of the tank away from its home. It may then come out to attack it or it may not. If it does attack, the square is withdrawn without giving any reward. It seems that if the animal is moderately well-fed the appearance of a moving object in its field of vision may or may not produce attack. Some octopuses come out on rather more than half the occasions, others rather less, but it is not possible to make an accurate forecast of whether the animal will come out on any given occasion.

We can alter all this if we give the octopus food after it has attacked the white square. When this has been done a few times, the animal begins to come out much more regularly and quickly. Soon it will be dashing out in one or two seconds every time that the square appears, just as it did to a crab, and we can safely forecast that it will do so on every occasion. Some change has therefore taken place in the nervous system, so that the figure which at first only sometimes elicited an attack now does so every time. The problem is to try to find out what this change is that, as we say, associates the square with food.

We can pursue the matter further by training the animal to attack one figure but not another. If we introduce a larger square, the octopus trained to attack the smaller one will probably come out and attack it. But if now, instead of food, we give it an electric shock, the animal retreats quickly back into its home. We then proceed by sometimes showing the small square and giving food, sometimes the larger one and a shock. At first the octopus will make mistakes, attacking the large and not attacking the small, but after only ten trials or less it will be evident that it has learned to make different responses to the two figures — to come out and attack the one but to stay at home when the other appears. This must mean that the octopus now carries in its brain images or representations of the two figures. When the small square appears, the picture of this formed on the retina somehow fits with the representation stored in the brain and associated with 'food,' so that an attack is produced, and conversely for the larger square. What are these stored records or representations and how are they preserved by the nerve cells? We can only produce a partial answer but before we try to do so we may notice that the octopus can store not just two but several such records.

TEACHING AN OCTOPUS TO REMEMBER

After an animal has learned to respond correctly to small and large squares, we can introduce another pair of figures, say, a rectangle, shown horizontally and vertically, giving food when one is attacked, and shock when the other. At first the octopus will make many mistakes, but after a while it will begin to attack the horizontal rectangle more often than the vertical one. While it is learning to do this we can test it with the old pair of figures and shall find that its responses to the squares are less accurate than before; it makes more mistakes. However, after a while the octopus responds on most occasions correctly to each figure.

We can now introduce a third pair, say a white circle and a black one, and teach the animal to respond by attacking one of these but not the other. Again there may be confusion over the old figures, but finally a state is reached in which the animal will make the right response to any one of the six figures on about eight out of ten occasions. So there must be six records or representations stored within the nervous system, at least partly distinct. Yet they all occupy the same brain and probably any given nerve cell is involved in carrying several of them. While these records are being 'printed,' as we may say, on the brain, the animal makes mistakes in identifying the figures it has already learned. When six figures have been learned the response is less accurate than it was with only two.

These results show some characteristic features of nervous systems. Unlike man-made calculating machines, they operate with a vast number of units, the nerve cells. Moreover, the behaviour of such a system is not determinate. It is found that cutting out a part of the mechanism involved does not remove the memory. The brain therefore does not always carry its messages along exactly the same pathways. This makes it difficult to compare with even our most elaborate calculating machines in which, if you press any given set of buttons, you will always get the same result, if the machine is working right, or a wildly wrong result if there is a fault in any one pathway. However, mathematicians and physicists have long been accustomed to deal with systems in which it is impossible to forecast the behaviour of a given unit; and yet we can say a great deal about the probable behaviour of the whole aggregate. Such statistical methods will certainly have to be used to describe the operations of nervous systems.

A 'NEUROTIC' ANIMAL

If we try to make an octopus discriminate between two figures that differ only slightly, we see the statistical working of the system very clearly. A good pair of figures to use is a square shown to the animal with its edges vertical and horizontal and the same square presented on edge, which we see as a diamond. If the octopus gets shocks from one of these and food when it attacks the other, it will for many trials attack them indiscriminately. Then, gradually, a slight tendency to attack the one more often than the other appears. In every ten trials there may be seven attacks on the square shown square and three on the one shown as a diamond that gives shocks. This condition may then continue for many days, the octopus getting neither better nor worse at it. One cannot forecast what it will do on any one trial but you can safely bet on the proportion of attacks over a number of trials. Some octopuses presented with a difficult discrimination such as this cease to come out at all. We can express this by saying that both the figures have become associated with the shock, or more picturesquely that the octopus has become 'neurotic' and will not come out. I prefer the first method of stating it because it shows that there is nothing especially mysterious about such behaviour. If the octopus system is slightly biased in the direction of 'no attack,' then with two nearly similar figures it will learn to attack neither. This would be good policy for a relatively unprotected animal like an octopus. If it results in the animal getting no food, then other types of behaviour appear, such as trying to get out of the tank between the trials, but that is another story.

If we are to understand how these systems for setting up associations work, we must study the nervous system itself. From the back of the eye of an octopus a great number of nerve fibres lead to a part of the brain, the optic lobe, containing a vast number of cells. Within this lobe bundles of nerve fibres run in all directions. Each fibre bringing signals from one part of the retina is thus connected with a number of the cells of the lobe. Moreover, these connections run in all directions in an irregular manner. Activity at any one point thus produces activity spreading away in all directions. When any pattern of light is thrown on the retina, as when, say, a square is presented, a most complicated system of interactions must be set up among the cells of this optic lobe. From this lobe, nerve fibres lead away to the nerve cells that control the muscles of the eight arms and swimming organs of the octopus, making the animal either come out to attack or retreat. We have seen that when an unfamiliar figure appears there is about a fifty-fifty chance that the octopus will attack it. If the nerve cells are connected up in an irregular way this is to be expected. The signals from the eye will be equally likely to make the cells of the optic lobe produce the output leading to 'attack' or 'no attack.' Each time that the animal receives food or a shock, however, the situation in the optic lobe is altered. A further influence is brought to bear on the particular set of cells that have been excited and some process of memory records the association of each pattern of excitation with either food or shock.

But these optic lobes are not the only part concerned in setting up the memory records. From them other nerve fibres run to a region that has as its sole known function the setting up of memories. Its proper name is the vertical lobe but we may without undue exaggeration call it the memory lobe. If we remove this lobe from an octopus that has learned to react correctly to, say, black and white circles, we find that its responses become much less reliable than before. In particular it often comes out to attack the figure from which it receives shocks. If the lobe is removed from an untrained octopus it will then be found to be difficult to teach it to attack one figure but not another. If the figures are nearly alike the attacks will continue to be made indiscriminately on both of them, although a normal octopus can learn to make the correct response on the majority of occasions.

So the position is that this lobe serves to make the memory more exact and especially to record the association between a certain figure and a painful stimulus. A good example of this action of the lobe is seen with octopuses that have been trained with two closely similar figures and have gone into the 'no attacking' or neurotic condition. If from such an animal we remove the vertical lobe it will lose its 'inhibitions,' as we might say, and come out and attack either figure, whether it receives shocks or not. The octopus has lost the record of the association of the figures with shocks.

Perhaps the most interesting feature of the structure of this vertical lobe is that it sends its message back into the optic lobe, from which it originally came. So it seems that the vertical lobe serves to print the memories more precisely by sending them round in a circle. The representation of some outside object that appears on the retina is thus first recorded in the optic lobe. The vertical lobe makes a record of what is in the optic lobe and then sends it back again to the latter. It is reasonable to suppose that each time the record is passed through one of the lobes some change occurs in the cells to make the record more permanent.

It is not known what changes in the cells are involved, but physiologists are beginning to work at this problem. It can be attacked in another way by making model nerve cells and connecting them up in appropriate ways, as has been done by Mr. W. K. Taylor at University College. With modern electronic techniques it is possible to make a unit that reproduces the relevant electrical properties of a nerve cell. These model cells can be connected up so as to activate each other just as the real ones do. Unfortunately, the electronic equipment required is relatively bulky. To imitate a nerve cell that in real life is a tenth of a millimetre across we require a whole shelf of radio valves, condensers, and so on. Obviously, therefore, it is difficult at present to make a machine that closely imitates the brain, with its millions of cells. Nevertheless it is possible to go some way. Mr. Taylor's machine has nine receiving channels, comparable with, say, nine cells of the retina. These are connected with sixteen model nerve cells according to the principles that we have been considering, which involve what we may call a random factor. In order to decide whether to join up any two units, a process essentially like that of spinning a coin is used. The result is that every receiving cell is connected with some of the model nerve cells and each of the latter is stimulated by several of the receptors. Moreover the nerve cells are connected with each other on the same principles. Two further ingoing channels correspond to food and shock, and the whole apparatus has two possible outputs, registering what we may call an attack or retreat.

SIMULATION AND STIMULATION

The machine is trained essentially like an octopus. The nine ingoing channels are arranged in three rows of three, so that by activating one set of them we can simulate the letter L and with another a letter T. Say we stimulate the five channels that represent L we find that the machine has an equal chance of activating the 'attack' or 'retreat' outputs. If it does the former we 'reward' it by pressing the appropriate button. Conversely, with the letter T we give 'punishment' by a stimulus equivalent to a shock. For the first few presentations responses will be more or less at random, but gradually more 'attacks' will be made when L is shown, more 'retreats' with T. The machine has thus come to store representations of these two figures, exactly as an octopus does. It will carry this memory for a time that depends upon the properties that we give to the model nerve cells. If it has been left to forget for a while, say, two hours, it will make several mistakes but then will learn again more quickly than at first, just as an animal or man would do. If we leave it longer still, its memory will fade away altogether but we could, in principle, prevent this if we made connections permanent after they had been used a sufficient number of times, which may perhaps happen in the body by a process of growth. The duration of persistence of the memory could presumably be increased by introducing a self-re-exciting circuit comparable to that of the vertical lobe, which would be equivalent to passing the same pattern through over and over again.

The idea of a machine that remembers is not new: indeed, there are many types of them in existence. What is new about Mr. Taylor's machine is that it uses, so far as possible, the principles of connection of nerve cells that are used by the nervous system. At the moment it can perform only certain rather simple operations because of the difficulty of providing it with a sufficient number of model nerve cells. One of its main uses at present is to test whether given theories of cerebral activity are correct, and perhaps what is even more important is the use of the machine to stimulate us to new thoughts about how brains operate. By this reciprocal stimulation there is a good chance that we shall ultimately solve two of our most important problems; namely, how to make our brains work better and how to make machines that will do some of our brainwork for us.

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Information and Memory

GEORGE A. MILLER

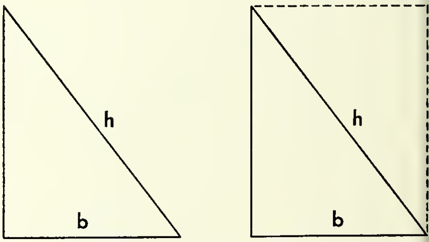
What person has not been annoyed by his memory limitations? Are our acts of remembering restricted to a certain number of units or is the size of the unit the important factor? How can we organize material to be learned to provide greater efficiency in dealing with complex symbolic behavior? This article is concerned with such questions and the experimental determination of the answers. The author gives us a little of the vocabulary of information theory and hints at the possibility of our learning about learning from the computers man has built to reduce mental labor.

Dr. Miller is associate professor of psychology at Harvard University. He has been investigating problems of communication and information for some years, chiefly at Harvard's Psychoacoustics Laboratory. *Scientific American* published the article which follows in August, 1956 (pp. 42–46). It is reprinted by permission of the publisher.

Some things are easy to remember. A short poem is easier to memorize than a long one; an interesting story is better recalled than a dull one. But brevity and wit are not all that is involved. Equally important is the way things fit together. If a new task meshes well with what we have previously learned, our earlier learning can be transferred with profit to the novel situation. If not, the task is much harder to master.

Imagine that you are teaching geometry to children. You have covered the business of calculating the length of the hypotenuse of a right-angled triangle when the base and the altitude are given. Now you are about to take up the problem of finding the *area* of a right triangle when the base and the hypotenuse are given. Suppose you were given your choice of the following two methods of teaching the children to solve the problem. In method A you would help them to discover that the area of a right triangle is half that of a rectangle with the same base and altitude, that the unknown altitude of the triangle in this case can be calculated from the given base and hypotenuse by use of the Pythagorean theorem, and that the area of the triangle can therefore be found by deriving the altitude, computing the area of the rectangle and then taking half of that. In method B you would simply tell the class to memorize six steps: (1) add the length of the base to the length of the hypotenuse; (2) subtract the length of the base from the length of the hypotenuse; (3) multiply the first result by the second; (4) extract the square root of this product; (5) multiply the positive root by the length of the base; (6) divide this product by 2.

Which method of teaching would you choose? Probably no one but an experimental psychologist



Two methods may be used to teach children how to find the area of a right-angled triangle. The method associated with the triangle at left has the following algebraic steps: (1) $h + b = v$, (2) $h - b = w$, (3) $v \times w = x$, (4) $\sqrt{x} = \pm y$, (5) $+ y \times b = z$, (6) $z/2 =$ area. The method associated with the triangle at right proceeds: (1) find altitude by the Pythagorean theorem, (2) find area of rectangle from base and altitude, (3) area of triangle is half the area of rectangle. The first method is considered ugly and the second efficient. Why?

would ever consider method B. Method A is productive and insightful; method B is stupid and ugly. But just why do we find method B repulsive? What is repugnant about a procedure that is logically impeccable and that leads always to the correct answer? This question is raised by the psychologist Max Wertheimer in his provocative little book, *Productive Thinking.* An obvious answer is that a child taught by method A will understand better what he is doing. But until we can say what it means to understand what one is doing, or what profit there is in such understanding, we have not really answered Wertheimer's question.

It is helpful to consider the interesting fact that method B is the procedure we would use to instruct a computing machine of the present-day type. The machine is able to perform arithmetical operations such as addition, subtraction, multiplication, division and the extraction of roots. Instruction for the machine consists in writing a "program" — like the series of steps used in method B except that the computer's program must be even more explicit and detailed, with even less hint of the basic strategy. Computing machine engineers have their hearts set on some day designing machines which will construct programs for themselves: that is, given the strategy for handling a problem, the machine will understand the problem well enough to create all the appropriate operations or subroutines required to solve it. The desirability of such a development is obvious. In the first place, at present it takes many hours of drudgery to write the detailed instructions for all the steps a computer must take. Then, after the instructions have been written, they must be stored in the machine in some easily accessible form. In a large machine the number of subroutines may run into the thousands; it might actually be more economical to equip the machine with the ability to create them on demand rather than to build the necessary storage and access machinery. In other words, in a very elaborate computer it would be more efficient to store rules from which subroutines could be generated than to store the routines themselves.

It seems, therefore, that even the computing machine realizes that method B is ugly. Each subroutine is an isolated operation that must be stored in its proper place, and no attempt is made to tie these steps to other information available to the machine. So we can see that one superiority of method A lies in the fact that it makes more efficient use of the capacity for storing information. In the teaching of geometry to a child, method A highlights the relations of the new problem to things that the child has already learned, and thus it provides the rules by which the child can write his own subroutines for computation. In essence the ugly method is less efficient because it requires the child to master more new information.

The intimate relation between memory and the ability to reason is demonstrated every time we fail to solve a problem because we fail to recall the necessary information. Since our capacity to remember limits our intelligence, we should try to organize material to make the most efficient use of the memory available to us. We cannot think simultaneously about everything we know. When we attempt to pursue a long argument, it is difficult to hold each step in mind as we proceed to the next, and we are apt to lose our way in the sheer mass of detail. Three hundred years ago René Descartes, in an unfinished treatise called *Rules for the Direction of the Mind,* wrote:

> If I have first found out by separate mental operations what the relation is between the magnitudes A and B, then that between B and C, between C and D, and finally between D and E, that does not entail my seeing what the relation is between A and E, nor can the truths previously learned give me a precise knowledge of it unless I recall them all. To remedy this I would run them over from time to time, keeping the imagination moving continuously in such a way that while it is intuitively perceiving each fact it simultaneously passes on to the next; and this I would do until I had learned to pass from the first to the last so quickly, that no stage in the process was left to the care of memory, but I seemed to have the whole in intuition before me at the same time. This method will relieve the memory, diminish the sluggishness of our thinking, and definitely enlarge our mental capacity.

Descartes's observation is familiar to anyone who has ever memorized a poem or a speech, or mastered a mathematical proof. Rehearsal or repetition has the very important effect of organizing many separate items into a single unit, thus reducing the load our memory must carry and leaving us free for further thinking. In terms of logic, the process is like the substitution of a single symbol for a longer expression which would be clumsy to write each time we wanted to use it.

The practical advantages of this unitizing process were vividly illustrated for me the first time I saw one of those digital computing machines that have small neon lights to show which relays are closed. There were 20 lights in a row, and I did not see how the men who ran the machine could grasp and remember a pattern involving so many elements. I quickly discovered that they did not try to deal with each light as an individual item of information. Instead, they translated the light pattern into a code. That is to say, they grouped the lights into successive triplets and gave each possible triplet pattern a number as its name, or symbol. The pattern all three lights off (000) was called 0; the pattern off-off-on (001) was called 1; off-on-off (010) was called 2, and so forth. Having memorized this simple translation, the engineers were able to look at a long string of lights such as 011000101001111 and break it down into triplets (011 000 101 001 111) which they immediately translated into 30517. It was much easier to remember these five digits than the string of 15 lit and unlit lights.

Reorganization enabled the engineers to reduce the original complexity to something easily apprehended and remembered without changing or discarding any of the original data. There is an analogy between this simple trick and the process described by Descartes. Each step in a complex argument is like a single light in the binary sequence. Rehearsal organizes the steps into larger units similar to the engineers' triplets. Repeated rehearsal patterns the long argument into larger and larger units which are then replaced in thought by simpler symbols.

The first person to propose an experimental test of the span of a man's instantaneous grasp seems to have been Sir William Hamilton, a 19th-century Scottish metaphysician. He wrote: "If you throw a handful of marbles on the floor, you will find it difficult to view at once more than six, or seven at most, without confusion." It is not clear whether Hamilton himself actually threw marbles on the floor, for he remarked that the experiment could be performed also by an act of imagination, but at least one reader took him literally. In 1871 the English economist and logician William Stanley Jevons reported that when he threw beans into a box, he never made a mistake when there were three or four, was sometimes wrong if the number was five, was right about half the time if the beans numbered 10 and was usually wrong when the number reached 15. Hamilton's experiment has been repeated many times with better instrumentation and control, but refined techniques serve only to confirm his original intuition. We are able to perceive up to about six dots accurately without counting; beyond this errors become frequent.

But estimating the number of beans or dots is a perceptual task, not necessarily related to concepts or thinking. Each step in the development of an argument is a particular thing with its own structure, different from the other steps and quite different from one anonymous bean in Jevon's box. A better test of "apprehension" would be the ability to remember various symbols in a given sequence. Another Englishman, Joseph Jacobs, first performed this experiment with digits in 1887. He would read aloud a haphazard sequence of numbers and ask his listeners to write down the sequence from memory after he finished. The maximum number of digits a normal adult could repeat without error was about seven or eight.

From the first it was obvious that this span of immediate memory was initimately related to general intelligence. Jacobs reported that the span increased between the ages of 8 and 19, and his test was later incorporated by Alfred Binet, and is still used, in the Binet intelligence test. It is valuable principally because an unusually short span is a reliable indicator of mental deficiency; a long span does not necessarily mean high intelligence.

A person who can grasp eight decimal digits can usually manage about seven letters of the alphabet or six monosyllabic words (taken at random, of course). Now the interesting point about this is that six words contain much more information, as defined by information theory, than do seven letters or eight digits. We are therefore in a position analogous to carrying a purse which will hold no more than seven coins — whether pennies or dollars. Obviously we will carry more wealth if we fill the purse with silver dollars rather than pennies. Similarly we can use our memory span most efficiently by stocking it with informationally rich symbols such as words, or perhaps images, rather than with poor coin such as digits.

The mathematical theory of communication developed by Norbert Wiener and Claude Shannon provides a precise measure of the amount of information carried. In the situation we are considering, the amount of information per item is simply the logarithm (to the base two) of the number of possible choices. Thus the information carried by a binary digit, where there are two alternatives, is $\log_2 2 = 1$ bit. In the case of decimal digits the amount of information per digit is $\log_2 10 = 3.32$ bits. Each letter of the alphabet carries $\log_2 26 = 4.70$ bits of information. When we come to make the calculation for words, we must take into account the size of the dictionary from which the words were drawn. There are perhaps 1,000 common monosyllables in English, so a rough estimate of the informational value of a monosyllabic word selected at random might be about 10 bits.

A person who can repeat nine binary digits can usually repeat five words. The informational value of the nine binary digits is nine bits; of the five words, about 50 bits. Thus the Wiener-Shannon measure gives us a quantitative indication of how much we can improve the efficiency of memory by using informationally rich units. The computer engineers who group the relay ights by threes and translate the triplets into a code can remember almost three times as much nformation as they would otherwise.

It is impressive to watch a trained person look at 40 consecutive binary digits, presented at the rate of one each second, and then immediately repeat the sequence without error. Such feats are called "mnemonic tricks" — a name that reveals the suspicious nature of psychologists. The idea that trickery is involved, that there is something bogus about it, has discouraged serious study of the psychological principles underlying such phenomena. Actually some of the best "memory crutches" we have are called laws of nature. As for the common criticism that artificial memory crutches are quickly forgotten, it seems to be argely a question of whether we have used a stupid crutch or a smart one.

When I was a boy I had a teacher who told us that memory crutches were only one grade better than cheating, and that we would never under-tand anything properly if we resorted to such underhanded tricks. She didn't stop us, of course, but she did make us conceal our method of learnng. Our teacher, if her conscience had permitted t, no doubt could have shown us far more efficient systems than we were able to devise for ourelves. Another teacher who told me that the ordinate was vertical because my mouth went that way when I said it and that the abscissa was horizontal for the same reason saved me endless confusion, as did one who taught me to remember the number of days in each month by counting on my knuckles.

The course of our argument seems to lead to he conclusion that method A is superior to the ugly method B because it uses better mnemonic devices to represent exactly the same information. n method A the six apparently arbitrary steps of method B are organized around three aspects of he total problem so that each aspect can be repreented by symbols which the student has already learned. The process is not essentially different from the engineers' method for recoding a sequence of binary lights.

It is conceivable that all complex, symbolic learning proceeds in this way. The material is first organized into parts which, once they cohere, can be replaced by other symbols — abbreviations, initial letters, schematic images, names, or what have you — and eventually the whole scope of the argument is translated into a few symbols which can all be grasped at one time. In order to test this hypothesis we must look beyond experiments on the span of immediate memory.

Our question is: Does the amount of information per item (*i.e.*, the number of possible alternative choices per item) affect the number of items we can remember when there is a large amount of material to be mastered? For example, is it more difficult to memorize a random sequence of 100 monosyllabic words than 100 digits or 100 letters of the alphabet? The question is important because it has a bearing on how we can organize material most efficiently for learning.

In an exploratory study that S. L. Smith and I devised at the Harvard University Psychological Laboratories, the subjects were required to memorize three different kinds of lists of randomly chosen items. One list was constructed from a set of 32 alternatives (all the alphabet except Q plus the numerals 3, 4, 5, 6, 7, 8 and 9), another from a set of eight alternatives, and the third from just two alternatives. The subject read a test list at the rate of one item every second and then had to write down as much of the list as he could remember in the correct order. The lists ran to 10, 20, 30 or 50 items. If the subject failed to reproduce the list exactly, it was presented again. The number of presentations required before the first perfect reproduction measured the difficulty of the task.

We were not greatly surprised to find that the subjects did somewhat better (*i.e.*, needed about 20 per cent fewer trials) on the binary-choice lists than on the other types. After all, a run of, say, six zeroes or six ones is easy to remember and therefore in effect shortens the list. But on the other two types of lists (eight alternatives and 32 alternatives) the subjects' performances were practically indistinguishable. In other words, it was just as easy to memorize a list containing a lot of information as one of the same length containing less information.

Very similar results have been obtained at the University of Wisconsin by W. J. Brogden and E. R. Schmidt, who did their experiments for other reasons and without knowledge of the hypothesis Smith and I were trying to test. They used verbal mazes with either 16 or 24 choice points and they varied the number of alternatives per choice point from two to 12. Here again the length of the list of points that had to be learned, and not the number of alternatives offered at each choice point, determined the difficulty of the test — with the same exception that we found, namely, that it was slightly easier to remember where only two choices were offered.

Tentatively, therefore, we are justified in assuming that our memories are limited by the number of units or symbols we must master, and not by the amount of information that these symbols represent. Thus it is helpful to organize material intelligently before we try to memorize it. The process of organization enables us to package the same total amount of information into far fewer symbols, and so eases the task of remembering.

How much unitizing and symbolizing must we do, and how can we decide what the units are? The science of linguistics may come to our aid here. Language has a hierarchical structure of units — sounds, words, phrases, sentences, narratives — and it is there that one should seek evidence for a similar hierarchy of cognitive units.

It has been estimated that English sentences are about 75 per cent redundant: that is, about four times as long as they would need to be if we used our alphabet with maximum efficiency. At first glance this fact seems paradoxical. If length is our major source of difficulty, why do we deliberately make our sentences longer than necessary? The paradox arises from a confusion about the definition of sentence length. Is a sentence 100 letters, or 25 words, or 6 phrases, or one proposition long? The fact that all our books contain 75 per cent more letters than necessary does not mean that 75 per cent of the ideas could be deleted. And it is those larger subjective units, loosely called ideas, that we must count to determine the psychological length of any text.

A sequence of 25 words in a sentence is easier to recall than a sequence of 25 words taken haphazardly from the dictionary. The sentence is easier because the words group themselves easily into familiar units. In terms of psychological units, a 25-word sentence is shorter than a sequence of 25 unrelated words. This means that the word is not the appropriate unit for measuring the psychological length of a sentence. Perhaps linguistic techniques for isolating larger units of verbal behavior will provide an objective basis for settling the question.

When we memorize a sentence, all our previous familiarity with the lexicon and grammar of the language comes to our aid. It is one of the clearest possible examples of the transfer of previous learning to a new task. And the transfer is profitable because it serves to reduce the effective length of the material to be remembered. By learning the language, we have already acquired automatic habits for unitizing those sequences that obey the rules of the language.

There are three stages in the unitizing process. All three were described in the 17th century by John Locke in his famous *Essay Concerning Human Understanding:* "Wherein the mind does these three things: first, it chooses a certain number [of specific ideas]; secondly, it gives them connexion, and makes them into one idea; thirdly, it ties them together by a name." Men form such complex ideas, Locke said, "for the convenience of communication," but the combination of ideas sometimes leads to confusion because it is "the workmanship of the mind, and not referred to the real existence of things." The development in the 20th century of a mathematical theory of communication enables us to see more clearly how this process serves the convenience of communication and, coupled with the fact that it is the length, not the variety of the material that limits our memories, gives us an important insight into the economics of cognitive organization.

Organizing and symbolizing are pervasive human activities. If we can learn to perform them more efficiently, perhaps we shall indeed be able, as Descartes promised, to "relieve the memory, diminish the sluggishness of our thinking, and definitely enlarge our mental capacity."

21

"Where Were You the Night of April 23, 1935?"

ROBERT G. WHALEN

At the time this article originally appeared newspaper readers were following a court trial of extraordinary interest. It was the sort of case where the evidence was complicated. The story resembled a cloak-and-dagger yarn. Witnesses were required to testify on small details of events which had taken place years before. As in most court testimony, questions arose about the ability of a person to recall such minute fragments of observation. For this article, Mr. Whalen collected information from psychologists and others on four questions concerned with learning and memory — What is it? How much is remembered? Is it reliable? and What about court testimony? The author tells us something about the limitations of memory, some of the peculiarities of memory, how it relates to the original learning process, memory distortions, and the role of associations or substitute stimuli in remembering.

Mr. Whalen is a member of the staff of the *New York Times*. His article on memory appeared in the *New York Times Magazine* of December 18, 1949 (pp. 18, 25, 27). It is reprinted, with the omission of a few paragraphs dealing with the trial, by permission of the author and the publisher.

WHAT IS MEMORY?

The psychologists say there is no over-all definition of memory. The reason is that the word "memory," as laymen use it, takes in several processes which to the psychologist are distinct. For example, there is recall, as when one tries to list the states and their capitals. There is recognition, as when one is shown a photograph and asked whose it is. Another process, which laymen do not usually think of as memory, is motor memory. This is what enables a person, say, twenty years after he had ridden a bicycle, to mount one and ride away without thinking twice about how to do it.

Altogether, these processes are exceedingly important to us. They are essential to learning. They enable us to use past experience as a guide for future action. With memory, a psychologist has written, ". . . the world escapes being an entirely new thing every time we perceive it."

Just how the memory works is largely a matter of speculation — and will presumably remain so until science learns a great deal more about the brain and our mental processes. However, the psychologists at least have come to some tentative conclusions.

One conclusion is that the phrase, "photographic memory," generally is a misnomer. We do not retain all the details of a past scene or event; those we do hold are recalled one by one, and not in a single, all-inclusive image. There are exceptions to this rule. For example, some children before adolescence have "eidetic," or unusually vivid, memories. In an experiment with English children it was found that some remembered the most precise details of a picture, including the spelling of a German word — *Gartenwirtschaft* — which was entirely new to them.

Another conclusion is that memory seems to be a sort of etching process. The longer an experience is allowed to sink in undisturbed, the more lasting it becomes. One indication of this is what happens when one has had a blow on the head or other accident. We often forget what has happened immediately before and after the shock, but our memory of long-past events is unaffected. The shock apparently wipes out the most recent memory before it has had time to etch itself very deeply.

A third conclusion is that memory seems to be a function of the whole brain, not of only a part of it. There used to be a theory that the seat of the memory was in the frontal lobes of the brain. In one experiment some cats were taught how to get out of a box, and then their frontal lobes were removed. The cats had to be taught the way out of the box all over again.

But to other cats who had been "over-trained" — taught so well that getting out of the box was second nature, so to speak — the loss of the frontal lobes made no difference.

HOW MUCH DO WE REMEMBER?

Not much, according to all the evidence. The first evidence came from a classic experiment in psychology, performed nearly a century ago by a German named Hermann Ebbinghaus. What Ebbinghaus did was to test himself with nonsense words — bap, tox, muk, rif, seiz. His theory was that these words, free of meaning or other associations, would provide a test of "pure" memory. He studied lists of the words until he could recite them once from memory. Then he retested himself.

Ebbinghaus found that he forgot 42 per cent of the words after twenty minutes; 56 per cent after an hour; 66 per cent after a day. After this first rapid loss, there remained a core of memory which shrank much more slowly.

Ebbinghaus and others later added considerably to this basic finding. For example, much depends on the way we use our memory. In study, more is remembered if one consciously commits material to memory — by reciting to one's self — than if one merely reads. It is better to study in relatively short sessions and by periodic review than in one long session. Dr. Mary Rose Sheehan, present head of the Psychology Department at Hunter College, says, "That is why we advise our students against cramming."

Much depends also on the nature of the experiences involved. We remember best the things that have interest and significance for us. Many of us have vivid memories of what we were doing on the afternoon of Dec. 7, 1941, but Dec. 6 is a blank. Everyone knows where the 6 should be on a watch face; it is important for telling time. But many of us forget whether our own watch actually has the 6.

One of the open questions of memory psychology is the effect of emotion — whether we tend to remember pleasant things and forget the unpleasant. This brings up Sigmund Freud, the founder of psychoanalysis. In his theories, the repression of unpleasant memories plays a large part. The idea is that we have a *super-ego* which drives the unwanted memories out of consciousness into the unconscious, causing all sorts of internal conflict. The psychologists' reply is that this is an ingenious theory and that Freud may be right, but that they would like experimental proof.

Some psychologists maintain that there is a drive which makes us tend to remember best those actions which we have not completed; that once an action is completed it tends to be put from the mind. Dr. Sheehan gives the example of a man who writes a letter, then carries it about in his pocket, forgetting to mail it. She observes: "A psychologist would say that he neglects to mail it because he has completed the most important task, that of writing the letter. Freud would say he did not want to write it in the first place. No single explanation may be perfect."

At any rate, all hands seem to agree on one point: there is no such thing as a "good memory." The reason is that several factors are involved in the quality of memory. One is rote — the way one learns the alphabet. Another is meaningfulness — the extent to which one grasps the sense of what is to be remembered. A third factor is visualization — the vividness of the image evoked by recall. A person may have a good rote memory and a poor visual one. Furthermore, visual memory may vary. One may have a clear memory for form and no memory at all for any color.

The psychologists do not have much regard for "improve-your-memory" devices. Most of these are systems for memorizing associations. For instance, on meeting a fat man, one is supposed to say to one's self something like, "Kelly — belly." But associations are tricky. On meeting the man again, one might even say, "Hello, Mr. Stomach." What has happened is that an artificial meaning has been substituted for the real one, and when the artificial meaning fails, nothing is left.

Thus the psychologists say that the best way to improve memory is to cultivate the grasp of true meaning. One experiment demonstrating this had to do with remembering this string of figures: 581215192226. One group learned the figures in groups of three: 581, 215, and so on. Another group learned it as the total of Federal expenditures in one year: $5,812,151,922.26. A third group learned it as a series beginning with 5 and proceeding with the addition of 3 and 4 alternately, thus: 5, 8, 12, 15, etc. In tests afterward the first group's rote method proved worst; the second group's more meaningful method was better, and the completely meaningful third method proved best.

IS MEMORY RELIABLE?

Not very, according to all the evidence. Not only do we remember only a small part of what we experience; much of what we think we remember may be false.

"He lies like an eye-witness" is an old German saying, and a German-born psychologist, Dr. Hugo Muensterberg, did much to prove its validity. Writing a generation ago, he told of the following incident — one which was so striking and was repeated so often by other psychologists that it became something of a professional cliché:

At Goettingen there was a meeting of psychologists and other scientists trained in observation. Suddenly the door was flung open. A man in clown costume rushed in, followed by a Negro wearing a black jacket, red tie and white trousers. The men uttered wild cries and scuffled on the floor. A shot rang out, and the men rushed from the room.

The incident had been secretly planned, rehearsed and photographed. The chairman of the meeting asked the scientists to write complete reports on what they had seen, to be used in the police investigaton which he said was sure to follow. Forty of the scientists wrote reports. None gave a complete account of the incident. Only six did not misstate some fact. Twelve missed 40 to 50 per cent of what had happened. Only four stated that the Negro had no hat; others reported that he wore a derby, high hat, and so on. His suit was described as red, brown, striped, coffee-colored.

Dr. Muensterberg often demonstrated the fallibility of eye-witnesses to his students by using them as the subjects of experiments. Once he held aloft for five seconds a white card pasted with fifty black squares. Afterward the students' estimates of the number of squares ranged from twenty-five to 200. He sounded two clicks ten seconds apart. Estimates of the interval ranged from one-half to sixty seconds; most put it at forty-five seconds. He asked how large an object, held at arm's length, would be required to blot out one's vision of the full moon. The answers included a cantaloupe, dessert plate, a quarter, half dollar, clock, carriage wheel, pie and — the correct answer — a pea.

All this demonstrates that poor observation frequently falsifies memory. Memory may be falsified further by suggestion and imagination. When a person has been shown a picture of a room and then been asked, "Are there two chairs or three?" the tendency is to say either two or three, although there may have been only one. When one hears a screech of tires and a crash, then turns to see the wrecked cars, there is a temptation to reconstruct the events leading to the accident — and to swear afterward that that was the way it happened.

Most of us are familiar with other quirks of memory. There is what the French call *déjà vu* — literally, already seen. It is the feeling that one is reliving an experience precisely as it was experienced before — at some time that cannot be pinned down. Psychologists have no sure explanation for this phenomenon.

Another familiar occurrence is that of suddenly encountering a friend or close relative and being unable to recall his or her name. (This writer had such a lapse with, alas, his wife.) This may happen when the person is encountered in circumstances and surroundings not usually associated with him — such as when a neighbor is met in a gathering of business friends.

WHAT ABOUT MEMORY AND THE LAW COURTS?

Lawyers have confirmed by experience much of what the psychologists have learned by experiment. It is a commonplace of the law that the reliability of a witness' memory must never be taken for granted. Even Muensterberg confessed that his memory once led him astray in dealing with the law. His home had been burglarized while he was on vacation. He told the police confidently that the "thieves" had left a paper-wrapped clock on a table and droppings of wax on the second floor, and that they had missed seven of his suits. It turned out that the clock was wrapped in a table cloth; the wax was in the attic; the seven suits were indeed stolen and there was only one thief.

In a kind of reverse twist, there was one case years ago in which justice was done because of a witness' faulty memory. A man named Twitchell murdered his wife. In order to throw suspicion upon an outsider, he went outside later and opened the gate. He was brought to trial anyway. The family servant, who had been in the habit of opening the gate every morning, testified that she had opened it this time, too. Twitchell was convicted. He thereupon confessed the entire crime.

Generally, the reliability of a witness may depend on several factors. Some factors may enhance his reliability, others may cast it in doubt. On the plus side, witnesses often are called upon to testify about events which have impressed them vividly. Justice Albert Cohn of the Appellate Division of the New York State Supreme Court, gives the example of a man who has been held up. "We can usually assume," he says, "that the victim of a holdup will have a lasting memory of the holdup man's face."

Moreover, the memory of a court-room witness is nearly always refreshed in advance. The lawyer who summons him prepares him by questioning him closely and emphasizing points of evidence to be borne in mind. Otherwise, the witness may prove to be an easy target under cross-examination. Part of the preparation may be examination of old records, correspondence or diaries. These, by recognition and association, may bring to mind large areas of recollection which otherwise might have remained hidden.

. . . .

But can testimony be reliable when it deals with events so long past? Can anyone truthfully answer such a question as: "Where were you on the afternoon — or night — of April 23, 1935?" (The date was suggested at random by the editor of this magazine.) Well, with a few minutes reflection and a glance at a calendar, this writer can give at least a partial answer. The date was a Tuesday, and Tuesday at that time was one of his days off. Given more time, some persons might be able to give a more complete answer by relating the date to family anniversaries, canceled checks, current news and the like.

In court the question is often put the other way round — a date is asked for a given event. A little self-examination will show that an answer may not be difficult. When did the writer acquire the typewriter on which this article was written? Easy. It was a birthday gift and its portability was soon put to use on an assignment to Annapolis. The periodical index proves the date was just over ten years ago.

When did he last lunch in a certain restaurant in Rockefeller Center? It was with Friend X and must have been a day or two after Feb. 5, 1937, because there was an argument about the "court packing" plan which President Roosevelt announced on that date. There was a discussion also about whether there was chicory in the salad. Such recollection is common.

On the other hand, lawyers say that when detailed testimony is offered in court it should be regarded with some skepticism. An attorney of forty years' experience at the bar maintains that it is difficult for a witness to present such testimony without exaggeration or misstatement.

There is also the factor of the witness' interest in the outcome of a case. This is apart from perjury; the witness himself may be deceived. Judge Cohn says: "The average person tries to be truthful, but if he has a personal interest in a case he may unconsciously color his testimony."

Altogether, the reliability of a witness may come down to a question not only of whether the witness is lying, but also of whether the witness' memory is lying.

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SUGGESTIONS FOR FURTHER READING

Gray, G. W., The Yerkes Laboratories. *Scientific American*, February, 1955, pp. 67–77. Two of the authors in Part III mention this famous center for psychological and biological research. Gray describes his visit to the laboratory and some of the significant research performed there.

Ittelson, W. H., and F. P. Kilpatrick. Experiments in perception. *Scientific American*, August, 1951, pp. 50–55. Similar in content to selection 14, but it contains some excellent photographs of several perceptual demonstrations.

Morgan, Clifford T., and James Deese. *How to Study*. New York: McGraw-Hill, 1957. This is a good example of the many student study guides available which show the application of learning principles to a practical problem.

Rock, Irvin. Repetition and learning. *Scientific American*, August, 1958, pp. 68–72. The author describes an interesting series of experiments which show that practice is critical for retention, but not for initial learning.

PART IV Behavior Is Variable

It was a wise Lincoln who said "Friend, the Lord prefers common looking people. That is the reason he makes so many of them." Many years later, a modern psychologist said that "people differ widely, but not wildly." Both of these men, keen observers of human nature, were aware of the patterning of individual differences. Although several patterns are known to exist, the most frequent is that which resembles the normal distribution curve. Many of us are "common looking" — just about average in physique and behavior, whereas relatively few of us are somewhat above or below average, and very few of us are far deviant in either direction. So there is variability among us in any dimension we examine — height or IQ, shoe size or ability to sing, strength of grip or tolerance for stress. Likewise there is variability within each of us — we may be average in height but uncommonly lyrical in voice, superior in IQ but with hard-to-fit feet, and so on.

The study of individual differences is a special field in several of the natural sciences. Both practical and theoretical ends are served by such study. It should be clear that the profession of vocational counseling is based upon the facts of differences in skills, aptitudes, and interests. Modern educational procedures are designed to consider differences in rate of progress. Or take religion, the arts, the professions, entertainment — anything in our culture — and consider what would happen if all people were exactly alike. From a theoretical point of view we describe human nature in terms of the characteristics of variability which we observe and measure. Then we attempt to understand it by designing experiments to uncover the multitude of contributing factors which mold the pattern. Prediction of behavior becomes possible from statistical analysis of data (based upon the same pattern) and leads to probability statements. Thus is our understanding verified.

In order to extend this basic concept of the variability of behavior, seven selections are included in Part IV. The first is an essay on the implications of individual differences for social structure. In the next two articles the sources of environment and of heredity are examined as contributors. In selections 25 and 26 the possibility of group differences (race and sex) are considered as sources for individual variability. Finally, in selections 27 and 28, the two great extremes of human ability — mental deficiency and intellectual superiority — are contrasted.

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Most Men Are Created Unequal

PAUL HORST

In this essay on human variability, the author makes an appeal for greater consideration of the differences in ability of individuals to contribute to society. Although he envisions an idealized state, he also recognizes the many difficulties which his theory would encounter if it were put into practice. In drawing up objections to his own proposal, he refers to traits of human nature, which themselves are variable characteristics, and which would interfere with the kind of social and political procedures he is considering. Even though the difficulties in a systematic application of practical procedures and theoretical principles from psychology are overwhelming, Horst's reasons for considering them are thought-provoking and informative. Equality of opportunity as defined in our political and social philosophy should never be confused with the fact of inequality of intellectual abilities and personality traits.

Dr. Horst is director of the Division of Counseling and Testing and professor of psychology at the University of Washington. He held several posts in personnel work before going there in 1947. The article that follows is based on his presidential address for the Division of Evaluation and Measurement of the American Psychological Association. It appeared in *Scientific Monthly* in May, 1951 (pp. 318–324), and is reprinted by permission of the author and the publisher.

It is a part of our great American tradition that one man is as good as another, if not a darn sight better. This point of view educators, politicians, and religious leaders have proclaimed for nearly two centuries. Since the time of Galton and Binet, however, a competing note has been struck. The burden of this note is, of course, that people do differ greatly from one another in many respects. The idea is not new to this century or even to this millennium. Plato in his *Republic* showed some knowledge of the phenomenon of individual differences and of its importance for the efficient operation of a political state. Some centuries later the most famous social philosopher of all time told a story about a man who divided his goods among his servants according to their differing abilities. Much earlier, a famous Jewish political and military leader used an aptitude test — strictly speaking, a performance test — as a basis for predicting individual differences in fighting ability. Coming down through the centuries, we arrive at a point in time when a great new nation was born and an ardent band of patriots declared, "We hold these truths to be self-evident, that all men are created equal." There has been a great deal of variation through the years and among various groups of people as to the seriousness and literalness with which this declaration has been received.

I do not want to assume the unpopular role of a debunker of our great American traditions. It would be instructive, however, to recall briefly the historical setting in which the concept of equality of men received its greatest impetus. I do not pretend to be a historian, but I believe it is common knowledge to every high-school student that the hereditary monarchies of Europe were by their very nature such that the correlation between the social power possessed by rulers, and their competence to administer this power in socially adequate ways, did not differ significantly from zero. It seems to me that the revolt of our forefathers was against systems of government that would allow power to fall into the hands of incompetent rulers. I question very seriously whether the mere fact of taxation without representation would have been enough to precipitate the Revolutionary War. If the decrees of George

III had accorded with the interests of the American colonists, the course of history might have been much different. I believe this observation is no more blasphemous than to note that in this country it is only when people are unhappy about current conditions that they flock to the polls to turn out the political incumbents.

It was obvious to many of us in World War II that distinctions in authority and responsibility symbolized by rank were very necessary for efficient operation. I do not believe that the resentment that was exhibited toward differences in rank (and it is pointless to attempt to minimize this resentment) was due to unwillingness of subordinates to recognize differences in responsibility and authority. I think the resentment here was the same as that of our forefathers, namely, that in many cases there was a marked discrepancy between rank and the competence of the person holding the rank. Many enlisted men could have discharged the duties and responsibilities of many officers more competently than the officers themselves discharged them. What servicemen justifiably resented was not the fact that there was not equal opportunity for all in the Army, but rather that opportunity was not always commensurate with ability. True, much of the disparity was due to the gigantic task of mobilizing and organizing many millions of individuals into a complex military machine as efficiently and expeditiously as possible. But the unfortunate fact remains that some persons in positions of considerable responsibility in the military services still subscribe to the criterion of seniority as the most satisfactory basis of promotion, and fail to recognize the significance of individual differences for the efficient operation of the armed services.

In developing his philosophy of the role of education in this country as a bulwark against Communist aggression, one of our leading educators insists that we strive to attain a classless society. As I understand it, this is a prominent feature of the Marxist philosophy. It seems pretty clear, however, that the Stalin regime early recognized how unrealistic and how psychologically unsound such a goal must be. Even the Soviets, with their artificial pressures and forces, soon realized that the phenomenon of individual differences could not be exiled to a Siberian prison camp. Our educational philosopher seems to regard a stratified society as the opposite of a classless society. This is a type of error that appears to be common to all human beings, including social philosophers. It is perhaps this tendency for human beings to categorize quantitative phenomena that is indirectly responsible for some of the resentment against the phenomenon of individual differences. We talk about the upper classes, the middle classes, and the lower classes, or, if we want a really fine breakdown, also the upper and the lower middle classes, so that we have five categories. I suppose the issue of a stratified society versus a classless society might never have become so acute if there had not been this insistence on drawing artificial and arbitrary cutoffs on the base line of distributions of individual differences.

Even leaders in the measurement of individual differences have committed this type of sin in specifying such categories as genius, normal, moron, etc., on the basis of whether a person happens to fall above or below an arbitrarily specified score. But the alternative to arbitrary categories is not the Procrustean bed of classless society. It is hard to see how in the long run any attempts to stretch the little people till they take the whole length of the bed and cut off the limbs of the tall people so that they will not project over it can possibly lead to a better world. As I have indicated, I am sure the rebellion of our forefathers, the resentment of enlisted military personnel, and the antagonism of the great majority of our American citizenry today toward people in positions of authority and power derive not from resentment at being placed below someone in some scale or other but from the feeling, right or wrong, that the people placed in such positions do not have the ability commensurate with the authority.

Why should we try to ignore or minimize the virtues of those who are superior to us, or the weaknesses of those who are inferior? We all know people who are superior to us in a great many respects, and no philosophy of equality or of a classless society — nothing we can do or say — will make them less superior. Why should they pretend that they are not superior in those respects in which they excel? Likewise, why should we deny that we are superior in many ways to many people, or why should they resent our superiority? It seems to me that efforts to insist on a classless society can result only in encouraging the demagogues who, under the guise of equality for all, establish police dictatorships in one country after another.

THE IDEAL SOCIAL STRUCTURE

People do differ, then, and these differences are extremely important when it comes to drafting a plan for an ideal social structure including its educational, political, and economic aspects. It is primarily those individual variations which differentiate people according to the effectiveness with which they react to their physical or social environments that concern the measurement psychologists. We are concerned with measuring individual differences in socially significant behavior, and I would say that the behavior that is rewarded or penalized by society is socially significant.

Why should the measurement and evaluation psychologist be concerned with the measurement of individual differences for socially significant kinds of behavior? The reason issues from an axiom which I hold to be more nearly self-evident than "all men are created equal." This axiom is quite simply that in general what a person receives from his fellow-men, when appropriately quantified, should be a monotonically increasing function of what he contributes to his fellowmen. Fundamentally, it is the old-fashioned idea of an honest day's pay for an honest day's work. By and large over a lifetime it seems reasonable that people should get out of this world about what they put into it. I am not concerned here with ethical or moral considerations. What I am saying is that, if adequate psychophysical means were devised for evaluating a person's contributions to, and requisitions from, society and the one plotted against the other, the points should define a curve whose derivative was at every point greater than zero.

If we are willing to grant that a relationship of this type between contribution and requisition is the ideal to be striven for, then we have the difficult problem not only of scaling the activities within a given type of social activity category but also the more difficult problem of equating the social value scales for one category of activity with another. It is the practical difficulties involved in attempts to develop scales of this kind that have led many people to throw up their hands and insist that it is meaningless to talk about the relative values of various types of human activity to society, and to insist on the futility of trying to measure what people get out of life.

Assuming that quantification is possible in this domain, let us not confuse the kind of rewards that consist of goods and services with those that are of a more abstract and emotional character. Consider, for example, the satisfaction that comes from achievement, the pride in a job well done, the adulation of one's neighbors or fellowmen. Consider also the rewards that are in the nature of promises — of a much better life in the future, or of land reforms, or of rule of the proletariat, or of a life of bliss and happiness in the world hereafter (even though in this life we sow that another may reap). Powerful and unscrupulous men in all ages, whether ecclesiastical, political, industrial, or what not, have capitalized on this type of reward to exploit the masses.

This is all by way of saying that an ideal social philosophy which takes account of individual differences in ability to contribute goods and services to society must also insist that the rewards be in kind. If we do not insist on this point of view we open the way, as indeed it has been opened in the past, to all manner of demagogues, whether they wear the cloak of the cleric, the robes of the monarch, the uniform of the soldier, or the plain suit of the businessman. This philosophy of payment in kind has been objected to by persons who point out that emotional and abstract rewards may be just as real and satisfying (if not much more so) as the more concrete rewards represented by conventional goods and services for which we pay our hard-earned money. I do not mean to say that such rewards have no place in our society; I am all for teaching people to enjoy work for the sake of personal achievement, to strive for the approbation of their fellow-men, to gain satisfaction in the knowledge that a better world awaits their honest efforts. But I do want to urge strongly that rewards of this type should not be acceptable as legal tender for genuine social contributions. Not only is this point of view important in order to keep demagogic aspirants and false leaders from counterfeiting social rewards in order to achieve power, but also to keep the inventories in the social warehouse at the maximum level.

To simplify subsequent reference let us call the theory of positive relationship between contribution and requisition merely the "positive slope theory." Hardly anyone will say outright, "No, I don't believe in this theory of a social state; I believe everyone is entitled to get as much in the way of goods and services out of this world as he can get away with, regardless of what his contribution might be." Most people will not make a statement as blunt as this, yet many will hesitate to subscribe wholeheartedly to the positive slope theory. Many of us secretly hope that luck will be in our favor and give us a little more than we really deserve. We have a hidden fear that, if there really were accurate means for measuring just what we requisitioned from the social contributions of others, and if there were something like a one-to-one relationship between the two, strictly enforced, then we might not get quite as much as we would otherwise.

I have not come to this conclusion hastily. I have observed for a good many years and in many different situations that people resent being evaluated with respect to socially significant activities. Take, for example, the use of employee-rating plans in industry. No matter how fair they are, they will always be criticized by influential elements in the particular social group concerned. Attempts to sell any system, no matter how reasonable, to teachers whose increase in rank or salary depends on ratings offer the same problems. The history of efficiency-rating procedures in the United States civil service records the stumbling blocks put in the way of the acceptance of any system. Efforts to establish several competing kinds of proficiency-rating plans in the military services both during and since the war provide an interesting commentary on resistance to precise personal evaluation.

There may of course be other interpretations of the opposition to systematic and formal evaluation instruments and techniques, but I think my interpretation is further supported if we observe that this phenomenon is closely related to the gambling tendencies of a large portion of the human race. Games of chance seem to have a basic human appeal. Mankind through the centuries has developed all sorts of formal procedures whereby one may risk a little to gain a lot. Recent developments in our large cities call attention to that widespread powerful and elemental psychological mechanism which is the motivation to gamble. It seems necessary to make something of an issue of this rather basic reliance on chance rather than on skill, because this tendency cannot be ignored in the design of an ideal social structure. The tendency is a most vital factor in our society and, so far as I can see, it is 100 per cent antithetical to the positive slope theory.

At the present time I am not satisfied with my own disposition of this phenomenon relative to the role of individual differences in an ideal social state. As a temporary improvisation, however, I am willing to say that, ideally, gambling should be regarded as a leisure-time activity in a rather narrow sense of the word, and that it should not be permitted to conflict with the positive slope hypothesis in an ideal social structure. I am not much impressed by the inevitable retort that you can't legislate human nature, for the evolution of civilized society has consisted in large part of the legislation and regimentation of human nature. This is not to say, of course, that human nature has taken it lying down or that in the future it will do so, but nevertheless, whether grudgingly, belligerently, or with alacrity, society has accepted increasing regimentation and must continue to do so as its structure becomes more complex.

The gambling instinct is one rather evident obstacle to the positive slope hypothesis, and if I did not believe so strongly in the hypothesis and its basic soundness for an ideal society, this all-too-human propensity would lead me to question its validity. I believe, however, that the difficulties inherent in any proposal for an ideal social state must be made explicit. And one encounters other problems in the positive slope theory. For example, should a person in an ideal society be permitted to exercise discretion as to the conditions under which he contributes either goods or services? Should he be allowed to give money, material goods, or his own skills to whomever he pleases under whatever conditions he pleases? In particular, should he be allowed discretion to convey his goods and services to other persons without reward or payment in kind? Our theory would indicate that he may not. If complete freedom of choice is given, then we open the way for unscrupulous political, ecclesiastical, or social organizations to employ techniques to influence people to part with their goods and services without appropriate compensation. In general, it would seem unsound to have no controls whatever on the rules by which a person may convey his goods or property. Shall we go to the other extreme and say that he may convey them only if he receives an equal amount of goods and services? Note here that the transfers would not necessarily be reciprocal. Usually, in a complex society they will not.

The family as an organic unit makes the positive slope principle difficult to apply. What shall be the contribution of the wife in exchange for food, clothing, shelter, entertainment, and what not provided by the husband? It seems quite natural to define bearing and caring for children as a social contribution, for without such there would be no society. But what about childless couples? What about homes well equipped with servants, so that the wife has nothing but leisure activities to engage in? The tendency for many married women, after maternal responsibilities have subsided, to get a job or to take on part-time work seems to be increasingly the vogue. I would say, then, that the trend is to recognize the responsibility of women to make socially significant contributions somewhat commensurate with their requisitions from society. But, even at that, the concept of the lady of leisure does not at present carry with it the opprobrium which the positive slope theory would attach to it. I suspect that in the ideal social state ladies of leisure must become obsolete.

But, even assuming that this species is gradually disappearing, certain theoretical obstacles persist. It is easy to argue that the president of a corporation might contribute enough to the social structure to entitle him to requisition from it a $50,000 yacht; it is easy to question whether the man who shines the president's shoes contributes enough to justify the requisitioning of a $50,000 yacht. It may be a little more difficult to argue that the wife of the industrialist contributes enough to society to justify her participation in the pleasures of a $50,000 yacht while the wife of the bootblack is denied them. So far I have no good rationalization for letting Mrs. President enjoy the yacht while denying this pleasure to Mrs. Bootblack. One could argue, of course, that because of the tendency toward selective mating Mrs. President could be expected to have the capacity for making a greater social contribution indirectly, through the achievements of her husband, than does Mrs. Bootblack through hers. But I am not convinced by this reasoning. One could argue that husband and wife are a single socially organic unit, and that the twain shall be one flesh until death do them part. Perhaps a somewhat better case could be made for this point of view.

But we get into still more trouble when we consider the children of the family. First, we encounter the problem created by inheritances. To what extent should a parent in an ideal social state be allowed to pass on to his children goods and privileges that he has accumulated? Property, including money, which is a form of communication specifying the amount of property one is entitled to requisition, does bestow social power and control upon individuals. The father who passes an inheritance on to his son passes with it social power and control. I have had students argue that a parent should have the right to pass on to his offspring the goods he has accumulated because this may be to the parent the highest possible reward for his lifetime of effort, and that to deprive the parent of the satisfaction of passing his goods on to his children would be a great injustice. I have already pointed out that the rewards for socially significant activity should be in kind. It seems to me this alone is reason enough why the argument of satisfaction to the parent is not adequate justification for passing his goods on to his children. But a more potent argument is the fact that in so doing the parent bestows power upon the heir. Should power or social control be bestowed upon children merely on the basis of the parents' economic status, or should this power be commensurate with the offspring's ability to make socially significant contributions?

Inheritances as such, then, are not in accord with the positive slope theory. The trend of our inheritance tax laws recognizes the fact that the socially useful abilities of children may not correlate significantly with the economic status of parents, but this is not to say that what they recognize is the positive slope theory. The inheritance tax trend is more in line with the Procrustean bed theory than the positive slope theory.

The problem becomes a little more complicated when we consider the early requisitions from the parents by the children. We may, perhaps, regard husband and wife as a single, organic, psychological unit and avoid the serious logical dilemma posed by children. It is only during their socially nonproductive period that children may be regarded as a part of a single organic family unit, for after they are grown and take their own position in society they must be looked upon as distinct units. Let us assume that society should provide life-preparatory opportunities for children according to some rule or other, whether it be for the purpose of equalizing adult abilities or whether it be concerned with providing opportunities commensurate with potential value to society. How would you prevent well-to-do parents from engaging the best private tutors, and from bestowing all sorts of cultural advantages upon their children which the poorer classes cannot afford?

Children of well-to-do parents, even though their potentialities to contribute constructively to society may be less than those of some economically handicapped families, nevertheless are bound to have greater opportunities under our present system. It is of little help for the development of a theoretical framework to point out that frequently the so-called opportunities of children in well-to-do families actually have a softening effect upon them, and do not prepare them as well to compete in life situations as do the struggles of those whose families are less able to requisition from the social warehouse. And even though police states have taken over much of what was formerly the parental jurisdiction of children and have demonstrated that it is possible greatly to reduce or minimize the influence of differences in home life and background, we should indeed seek far for other solutions to the problem before accepting these.

It may of course be that, with the sharply graduated income tax system, and a greater expenditure of tax money on better schools, better teachers, more parks, playgrounds, museums, and libraries, and other free cultural and educational opportunities for children, the disparity between the effective opportunities which the various economic classes can provide their children will continue to shrink. This may actually be the solution that is under way at present. We can see, then, that the positive slope theory has some inherent difficulties because of the role of the family in our culture as an organic social unit. It is the temporary character of this role that causes the trouble, for it is only after the unit breaks up that the children become, in any appreciable sense, contributors to society. At that time, however, the life-preparatory activities have already drawn upon the social warehouse in some fashion, whether in conformity with an acceptable social philosophy or not.

Another fundamental difficulty with the positive slope theory, which it is only fair to emphasize, is concerned with the quantification of social contributions and withdrawals. Presumably psychophysical scaling techniques can be worked out or adapted from those already available, for quantifying the values of goods and services over rather wide areas. But the value of a specifically defined kind of socially useful activity may vary widely for individuals or groups of individuals over a period of time, so that we have temporal variation in the value of a social contribution both among individuals and for a given individual. This phenomenon greatly complicates the implementation of a positive slope philosophy, but I do not think that it is inherently inconsistent with the theory. We might regard one kind of socially useful activity as that which provides the shifting evaluation of goods and services. Here, of course, we refer to all sorts of buying and selling activities for purposes other than direct consumption. In fact, many argue that a free market in which supply and demand determine the relative value of various goods and services is the most practical kind that can be devised for quantifying their shifting social values. The evils of an uncontrolled system in which private operators may artificially influence the direction and extent of price variation have long been recognized, however. Many of the safeguards provided by legislators for those who buy and sell for investment and speculation indicate an acknowledgment of the need for systematic control over the temporal variation of prices. Nevertheless, the systematic controls exerted by the government may be just as arbitrary as those of private individuals manipulating the price structure for their own advantage.

It is certainly imperative that, in the ideal social state, completely adequate operational definitions of the social values of goods and services be clearly formulated. The economic disaster of 1929 showed that an uncontrolled market was in no sense adequate to insure that anything remotely resembling a positive slope system would operate automatically.

Quite clearly, if some people requisition more than they contribute, then others must contribute more than they requisition. If only a few people requisition a great deal more than they contribute, so that a great many people contribute only a little more than they requisition, then we call the excess requisitioners brilliant financiers and set them on pedestals and hail them as elder statesmen. One such operator who has been extremely successful in stock-market operations has pointed out publicly that his success is based on the fact that he has done just what people wanted him to do. When people were extremely anxious to buy industrial securities, he would sell to them, and when they were extremely anxious to sell, he would buy from them; so by doing what his fellow-citizens insisted that he do he became wealthy. I point out this particular example because it shows the dangers of accepting uncritically the evaluation mechanism of uncontrolled market buying and selling, and of assuming that people should be given unlimited discretion as to the values they place on goods and services. It is hard to make a good case for the social value of buying and selling for purposes other than for processing, consumption, or to make goods more readily accessible to potential consumers.

EVALUATION AND MEASUREMENT IN PUBLIC SERVICE

I have discussed the importance of individual differences in socially significant activities, of the role to be played by a theory of monotonically increasing function between contribution and requisition, of the importance of measuring contribution and requisition accurately, and of the difficulties involved in accurate measurement in this area. Let us consider, finally, how evaluation and measurement might operate in the public service field, where we have been most prone to take for granted the dictum that all men are created equal. Should all men have an equal right to vote? Is voting a right or a responsibility? Certainly we have all had the experience of going to the polls and seeing on the election ballot the names of people we had never heard of, who were candidates for offices we didn't know existed. The question may well be raised whether we have either the right or the responsibility to vote for unknown candidates for unknown offices. Presumably, if the offices are important, and the functions are important to the local community, then it is essential that they be filled by qualified individuals. Certainly the way to get them filled by qualified individuals is not by any form of lottery system.

I have taken the extreme case of voting for minor local officials, but it seems to me the same principle applies to all elective offices. How much do you and I or the average citizen know about the particular qualifications and abilities required of the ideal governor of our state? How much do we know about the extent to which competing political candidates actually have these qualifications? As a matter of fact, how much does the average voter know about the abilities required of an effective President of the United States, and how much does he know about the extent to which political candidates possess these qualifications? Other things being equal, shouldn't the person who knows a great deal about the job requirements of a political office and the job qualifications of the various political candidates for that office have more to say in the selection of the official than the person who knows nothing about the qualifications of the candidate or the requirements of the job? If we grant this, we clearly imply that there should be a set of examinations to test knowledge of job requirements and knowledge of the qualifications of candidates. To keep the system relatively simple, one might have a qualifying score, with only those above the score entitled to vote on a particular candidate.

There is, of course, another approach to the selection of public servants, exemplified by the civil service system. The question may well be raised as to what kinds of public service jobs should be filled by means of elections and what kind by means of civil service examinations. Current practice implies that people should be required to demonstrate qualifications for the job only if the job is unimportant. If the job is of extremely great importance, then it becomes less necessary that the candidate be required to demonstrate his qualifications for it, whereupon Lady Luck exercises greater control.

It seems to me that one of two methods, or a combination of both, is available for exploiting the phenomenon of individual differences for the improvement of government. An obvious step would be to extend the civil service system to include more and more elective offices. Indeed, why should not our United States congressmen and senators be required to demonstrate their selective proficiencies in science, economics, sociology, political science, and other fields of knowledge relevant to intelligent legislation? As a matter of fact, it might not be too much to ask that a candidate for the presidency of the United States have some knowledge of the forces that influence the state of health of our national structure and that he be called upon to demonstrate at least a bare minimum of such proficiency.

We could, then, directly approach the problem of an improved governmental structure by insisting that relevant individual differences be measured and only the most competent be selected for office. If this method were carried to the limit, it would mean that all public offices would be filled from civil service examination rosters, and that elections would become a thing of the past. Apart from the theoretical difficulties involved, the sentimental and emotional barriers to the elimination of the voting system would probably be insurmountable. Another alternative would be somewhat arbitrarily to define, as we do now, the jobs to be filled by examination and those to be filled by election, but to capitalize on individual differences among the voters to be sure that only the most competent to vote would be permitted to do so. In the first case, the candidates would take the examinations, and, in the second, the voters would take them, allowing the candidates to establish their candidacy very much as at present.

Of course, if we really took individual differences seriously, and we wanted to make the most of them to ensure topnotch public service personnel, we could combine the two systems. In this case, the candidates would have to pass qualifying examinations before being allowed to run for offices, and the electorate would have to pass appropriate examinations before being allowed to vote for candidates.

Aside from the sentimental objection that all men are created equal, there are at least two fundamental difficulties involved in a recognition of individual differences in the political area. The first is a question of who would prepare the examinations. I mention this objection first because it is the one most frequently raised against a proposal of this kind. Until the time seems ripe for a definitive answer to the question, I would prefer to answer it with further questions. For example, who prepares the examinations for our present civil service positions, both Federal and local? Is the problem of extending civil service examinations to positions of greater responsibility any different in principle than the present civil service examination system? Who qualifies the candidates for our primary system at the present time? Would it not be feasible to establish examination commissions by means of rationales which would be at least as acceptable as those on which our current political machines operate, once people got used to the idea? Presumably some sort of ultimate examination commission would have to be established, whose members were as competent, objective, and incorruptible as the members of the United States Supreme Court are supposed to be.

A somewhat greater theoretical difficulty that I envisage with any system requiring qualifying examinations for the electorate is based on the assumption that what would be best in the long run for the qualified electorate would also be best for those who do not qualify. A system of qualified electors would involve at least two important basic assumptions: first, that the electors would know how to vote, not only for their own best interests, but also for the best interests of their less competent fellow-citizens; second, in the light of what would be best for the country as a whole, that guarantees could be incorporated into the system to see that the electors voted for the benefit of all. Such guarantees would be difficult, but I think not impossible to establish.

In conclusion, I shall admit freely that there are many obstacles to the achievement of a social system that rewards its members according to their contributions and utilizes fully the phenomenon of individual differences for the benefit of all. Nevertheless, I believe the highest goal that measurement and evaluation psychologists can strive for is the development of those instruments and techniques required by a society which aspires to capitalize to the fullest upon the fact that most men are created unequal.

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How Fair Is an IQ Test?

ALLISON DAVIS AND ROBERT HESS

No one has been more critical of the concept of "general intelligence" and the IQ as a measure of it than have psychologists themselves. We have known for some time that an intelligence test is, of necessity, deeply tied in with some cultural pattern. Hence when it is used to measure the intelligence of persons brought up and continuing to live in differing cultural milieux, the results may well indicate differences which do not matter when the intellectual environment is properly considered. One conclusion which seems to be apparent is that variability in intelligence within the United States is partly a reflection of a range of social, economic, and cultural stimulation. The authors of this article explain some of their attempts to devise an intelligence test which will be rooted in the "common culture" of all groups. In defense of the use of general intelligence tests in the public schools, which these authors criticize, it should be pointed out that as predictors of success in our typical school requirements, these tests are clearly useful.

At the University of Chicago Dr. Allison Davis is professor of education and Dr. Robert Hess is Dean of Students in the Division of Social Sciences. The studies which they discuss here are a part of one of the most extensive investigations of intelligence measurement yet undertaken. Their article originally appeared in the January, 1951, issue of *The University of Chicago Magazine* and is presented here as condensed in *Science Digest*, May, 1951 (pp. 43–47). Permission to reprint was granted by *Science Digest* and *The University of Chicago Magazine*.

Though many adults may have escaped taking an intelligence test, today most of America's 20 million children of elementary school age have not.

In many cities, and in both private and public schools, every child is tested not once but several times during his first eight years in school. Upon the basis of his scores on either intelligence or reading tests, he may be placed in a so-called "fast" or "slow" section, or even be sent to a "fast" or "slow" school.

An intelligence test, it is claimed, can measure real "mental ability." If we grant that present tests are accurate we must then accept their findings — that rural children, on the average, are definitely inferior to city children in intelligence; that white children in the South are less intelligent than white children in the North; that youngsters from the lower socio-economic levels in any American city rank about 8 to 10 IQ points on the average, *below* those from upper-class levels. By the time they are 13 and 14, on the average, they lag behind by 20 to 23 IQ points!

The men who make the tests, like Terman and Otis, say these wide variations can be traced to actual "genetic superiority" or "genetic inferiority." Yet there is no evidence from the science of genetics to support the view that any socio-economic class has greater claim to hereditary intelligence than any other.

At the University of Chicago, we are now engaged in studying this crucial problem: whether the wide variations in average group IQ's may not be chiefly a function of the kinds of problems and language used in the tests themselves, rather than of heredity. A research team, comprising Allison Davis, Kenneth Eells, Robert J. Havighurst, Ernest Haggard, Robert D. Hess, Walter Murray, Ralph W. Tyler and W. Lloyd Warner have been at work on the project for five years.

Dr. Eells began by studying the relative success of some 5,000 upper and lower social-class school children, living in a midwestern city. They answered 460 problems which are now incorporated in the 10 IQ tests most widely in use. In these 10 tests, there was not a single problem on which the children from low occupational and foreign background groups made superior scores to those of higher status. They managed to equal them on only 21 of the 460 problems, or less than five percent.

Eells found, as well, that the amount of difference between the two socio-economic groups varied, depending on which test was used. This made it clear that at least part of the "class difference" must result from factors in the tests themselves.

Let us state the central problem in this way: in life as a whole, human beings engage in an amazing variety of mental activities. To measure the general ability of one person, as compared to another, the test-maker must select types of problems which best represent this great range of human mental behavior. The evidence shows clearly that today's test-makers have *not* included a wide range of mental problems in their tests.

Rather, they pose academic problems, the kind which are taught in the average classroom and which do not stem from real-life situations at all, but from a highly traditional, unrealistic middle-class school culture.

The cultural group which all present IQ tests favor is the middle class.

This is no minor problem. For in our country as a whole today, more than 60 out of 100 children live in families belonging to lower socio-economic groups. In elementary schools, the ratio is 70 out of 100. The majority are native white, but millions more are Negroes or from white foreign-background stock.

On the other hand, 95 out of 100 teachers come from the middle classes, and from a cultural way of life markedly different from the majority of their pupils.

In the public schools of America, actually, there exists a great cultural divide. The lower-class children do not understand, and therefore cannot learn well, the teacher's culture. In turn, the teachers, and in lesser degree the social workers and clinicians, are trying earnestly to change the culture and basic way of life of more than half the children of America.

Small wonder they admit to feeling chronically anxious or "worried" and suffer a deep sense of failure, as a result of their honest, but ineffective efforts to help these children learn the school's culture.

They also face the extremely difficult task of trying to help children learn an unrealistic and extremely uninteresting curriculum.

The experiences symbolized in the textbooks of the first three or four grades, for example, are far more simple than those which the child has already met in his daily life. The stories seem foolish to lower-class children because the incidents appear unreal, the words strange. To the middle-class child, the drive of seeking his parents' and teachers' approval is usually strong enough to keep him trying, but not strong enough to make him like reading.

To test our hypothesis that present test-problems use cultural experiences and words which are more familiar to the higher socio-economic groups, Prof. Haggard and our staff carried out another experiment with 656 pupils. First we gave them the standard verbal tests, and then a number of additional problems which we had tried to make "culturally fair."

On certain types of these "culture-fair" problems, such as analogies, we found the lower groups showing marked improvement in performance. To cite just one case. . . .

In the standard IQ test there is a problem of this kind:

A symphony is to a composer, as a book is to what?

____ paper; ____ sculptor; ____ author; ____ musician; ____ man.

On this specific problem, 81 percent of the higher socio-economic pupils marked the correct answer. Only 52 percent of the lower group did.

Our new question yielded far different results. It read:

A baker goes with bread the same way that a carpenter goes with what?

____ a saw; ____ a house; ____ a spoon; ____ a nail; ____ a man.

This problem, using fair and simple words like "baker," "spoon," "nail," etc., was tougher intellectually for both groups and was therefore more honest and effective in helping spot the *most* able children. As a matter of fact, the proportion of correct answers was the same for both lower- and upper-class groups. (You may think that culturally this problem favored the children of unskilled and semi-skilled workers, which we defined as our lower economic group; actually it did not, for carpenters and bakers are seldom seen working or living in slum areas.)

To clinch our case — now that we knew how to remove the cultural bias from present test problems — we checked our work by seeing whether we could deliberately make a problem much harder for the lower groups. So we took a problem like this, used in present tests:

A person who by mistake hits another person should:

____ say that he did not; ____ forget it; ____ say nothing; ____ leave; ____ beg pardon.

To introduce a greater verbal and cultural bias, we made it read:

A child who unintentionally injures another child should:

____ deny it; ____ make amends; ____ flee; ____ be reticent; ____ ignore it.

By using unfamiliar "literary" language, and making reading as well as vocabulary very important in the solution of the problem, we discriminated quite severely against the youngsters from the lower classes. Accordingly, they came out no less than 32 percentage points below the upper socio-economic group.

Yet after four years of research, we at first were inclined to accept the opinion that children from the lower occupational groups were, on the average, inferior in real intelligence. For there still was not a shred of statistically valid evidence that, on any range of mental problems, the lower occupational groups could do as well, in terms of absolute attainment, as the higher occupational groups.

So we set up "experimental" individual and group tests, using three-dimensional objects, words and pictures which are familiar to all the cultures, and then expressing, with these common symbols, the kind and range of problems found with equal frequency among all groups.

We did not try to make a "culture-free" test, since this is a human impossibility, but a "common-culture" or "culture-fair" test of intelligence. This, we hoped, could measure real genetic-developmental differences between individuals more truly than do present IQ tests.

The problems were constructed according to these principles:

1. The *materials* used in the problems should be equally familiar, or unfamiliar, to both high- and low-status children.

2. The *words* should be drawn from a vocabulary common to both.

3. The *mental* task involved should not be a task likely to have been emphasized or taught, in either the home or school, to children of any particular class.

4. The problem should be *intrinsically motivating* to children of all levels.

We are *controlling*, in short, rather than *eliminating*, cultural factors in the testing.

Hess assembled problems for an individual test for pupils of six-and-a-half through nine-and-a-half years of age. Then trained graduate students administered the test to 545 public school pupils in Chicago. The youngsters came from three broad groups, according to the occupation of their fathers: high-status white children, whose parents were professional or managerial people; low-status white children, whose parents were unskilled or semi-skilled workers; and low-status Negro children, whose parents were unskilled workers or unemployed.

On a standard IQ test, the low-status white group scored nearly eight points *below* the high-status white group; but on the new test, it equalled them at each age level. The low-status Negro group averaged 20 IQ points below the high-status white group on the usual IQ test. On the new test, though they averaged somewhat lower than the two white groups, the IQ score-advantage of the high-status white group was substantially reduced.

As we indicated, one of the basic aims of our new test was to measure mental ability, not educational achievement. Performance of both high- and low-status-class pupils on the experimental test does not deny that the former can read or write better, on the average, than the latter, for they are better motivated to do so. It does suggest, however, that on those problems with which he is equally familiar, the low-status child can match the problem-solving ability of the higher-status child. A bright child is apt to be even "brighter" if his father is a solid citizen in the community, but the intelligence of an equally bright child is apt to be underestimated if he does not show the middle-status traits of neatness, cooperation, docility, cleanliness, and eagerness for school tasks. It is important for teachers to understand this tendency to overvalue and label as "intelligent" certain patterns of behavior which are, perhaps, completely irrelevant to the question of mental endowment.

Our findings also imply a responsibility for keeping open the routes of upward social movement, to the youth of the United States, through education and training. We do not mean that the culture of high-status groups should be imposed upon bright children of low-status levels. But certainly every reasonable effort should be made to help the child with talent to move into higher economic and social levels, if he so chooses.

Opportunity for climbing the social and economic ladder is one of the genuinely democratic aspects of American life; these channels must be kept open for the great numbers of children who are talented but underprivileged.

24

The Genetic Approach to Human Individuality

LAURENCE H. SNYDER

The roles heredity and environment play in the determination of individual differences are of more than ordinary interest for most students. Significant theoretical and practical implications are involved here. Specialists emphasize the need to consider always the interaction of variables from the two sources; it is not a matter of choosing one or the other as a determiner. Dr. Snyder, a geneticist, presents the case for genes, gene combinations, and mutations as contributors to individuality. He shows the part genes play in influencing certain physiological traits, how they are known to contribute to metabolic irregularities, and how these in turn are related to certain psychological variables. The twin method of studying hereditary factors is described, and the principles of population genetics are related to the more familiar Mendelian principles.

Dr. Snyder was Dean of the Graduate College, University of Oklahoma, until his recent appointment as President of the University of Hawaii. He has published extensively in the field of genetics. The article below is based on a paper he presented in a symposium at the centennial meetings of the American Association for the Advancement of Science. It appeared in *Scientific Monthly* for March, 1949 (pp. 165–171), and is reprinted by permission of the publisher and the author.

Note: A table has been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the author's permission.

No two human individuals are exactly alike. Variability is as much of a characteristic of human beings today as it is of all other species, and has been of living things throughout evolutionary history. Although no two persons are exactly alike, all human beings possess certain traits in common, and show certain similarities. The similarities and differences observable and measurable among people are the results of the interaction of genetic and environmental influences. It is becoming apparent that only modern genetic methods can successfully distinguish between the relative contributions of these interacting influences in bringing about human traits, and that the proportionate extent of these contributions will differ from trait to trait.

Human beings are most similar in those characters they share with the greatest variety of other animals, and differ from each other more and more as they get farther from these basic deep-seated traits and into the more superficial characters. We are chordates and we all have at an early stage in development a chorda, dorsal to the alimentary tract. We must assume that this is a hereditary trait, but we cannot specify the genes that result in the presence of a chorda, since we have never been able successfully to cross a chordate with a nonchordate and thereby to analyze the genes involved.

The fundamental chordate pattern is a remarkably constant characteristic of human beings. This may be due to the fact that whatever genes are involved in the production of this pattern are exceedingly stable and develop in relatively constant environmental surroundings, or it may very well be that any mutation interfering with this fundamental pattern is lethal. Living organisms, as a result of long ages of mutation and selection, have become highly adapted and delicately adjusted mechanisms, and fortuitous mutations, except those involving superficial characters, are apt to be, to say the least, harmful. Your watch is also a delicately adjusted mechanism. A fortuitous mutation might be likened to the result of jabbing an ice pick into a watch. If you jabbed enough ice picks into enough watches, you might come up with a revolutionary improvement in watchmaking, but the usual result would be to interfere with the normal working, or to stop the watch altogether.

Similarly, we are vertebrates and possess an ossified skeleton, much of which was preformed in cartilage. Mutations that prevented the appearance or development of the skeleton would most likely be lethal, but minor viable variations can and do occur, and these variations interfere more or less with normal functioning. More than one hundred mutations involving the skeleton are known in man, variously affecting the vertebral column, sternum and ribs, the skull, the pelvic and pectoral girdles, the long bones, and the bones of the wrist, hand, ankle, and foot.

Our mammalian characters of hair, mammary glands, and control of body temperature are somewhat less constant. Various mutations result in complete absence of hair, in excessive growth of hair, in persistence of lanugo hair, in complete absence of sweat glands, and in variations in the number, position, and functioning of the mammary glands. Here a mutational change can often be compensated for by man's ingenuity in controlling his environment. Thus we provide ourselves with varying degrees of clothing, with various hormone preparations, and we successfully feed and rear infants in the absence of human milk.

As we consider those traits that distinguish man taxonomically, we find such characters as the upright position, binocular vision, the opposable thumb, the development of the speech areas and the neopallium, and the loss of the external tail and body hair. Although mankind as a whole could probably not have developed to its present position without these traits, individual human beings can exist, with the aid of fellow-men, without one or more of these characters. Hence we find in any human population today considerable variability in these attributes.

Within the species *Homo sapiens* there are many variations known to have a genetic basis. Through geographic or social isolation, and the concomitant effects of inbreeding, genetic drift, and selection, a number of populations have become more or less differentiated one from the other in respect to one or several of the more readily recognizable of these variations, such as skin color, hair form, or stature. Such physically differentiable populations have been variously referred to as races, strains, peoples, or ethnic groups. It should be noted, however, that from a genetic standpoint, these groupings have little resemblance to the races or stocks of the laboratory geneticist. Through systematic and intense inbreeding, the usual laboratory race has been made very nearly homogeneous in respect to its entire genotype. Whatever homogeneous human races may once have existed have been largely obliterated as such by migration, with consequent interbreeding and genetic segregation.

Within any existing population of human beings there are genetic and environmental variations of so many and diverse sorts that each human individual is unique. These variations have been the subject of study by many groups of investigators: philosophers, physicians, anthropologists, psychologists, biochemists, and geneticists. With the development of modern scientific methods fruitful results are rapidly accumulating regarding human individuality.

The twentieth century has witnessed the remarkable development of the understanding of the principles of heredity. This development includes not only the classical principles of the transmission of chromosomes and genes, but their physiological and biochemical activities, their evolutionary history, their distribution and behavior in populations, and the social, medical, and legal implications of many of the traits resulting from them. The understanding of these principles has given us the first clear insight into human individuality.

Based on the studies of salivary-gland chromosomes in *Drosophila,* a reasonable estimate of the minimum number of pairs of genes on a pair of chromosomes would be 500. With 24 pairs of chromosomes, we could reasonably assume a minimum of 12,000 pairs of genes in man. Given a mutation at each of only 200 of these loci, the number of possible phenotypically different combinations would be 2^{200}, or approximately 1 followed by 60 zeros, even if dominance were complete in all instances. If dominance should not be complete, so that the heterozygote were phenotypically recognizable, or if more than one mutation has occurred at a locus, resulting in multiple alleles, the number of distinct phenotypes that could result from combinations of genes at 200 loci might well exceed the staggering total of 3^{200}, or approximately 1 followed by 143 zeros. Either of these numbers far exceeds the number of human individuals who have ever lived on the earth. Evidence is accumulating that many human genes long supposed to show dominance are actually recognizable in the heterozygous state.

Mutations are now known in man at far more than 200 loci. True, the mutant gene of the pair is often rare in comparison with the original gene, so that certain combinations of mutant genes will be exceedingly rare, but through the workings of Mendelian heredity all the various combinations are potentially possible, and many of them will occur with reasonable frequency.

I

Let us examine some of the better-known mutations and assay their contributions in producing human individuality. One of the first pieces of research undertaken in my laboratory more than twenty-five years ago was the analysis of the inheritance and distribution in populations of the blood groups. At that time we knew only four blood groups, and we were able to confirm the hypothesis that their inheritance was on the basis of a set of three multiple alleles. Today, because of the researches of workers in many laboratories all over the world, we know more than two million blood groups, dependent upon ten or more sets of alleles. The inheritance of the groups is rather well known. The blood groups have been described in detail on many other occasions, and I shall do no more than list them here (Table 1).

Table 1. The Known Human Blood Groups

Blood Group Systems	Number of Phenotypes
O, A^1, A^2, A^3, B, A^1B, A^2B, A^3B	8
Secretor, non-secretor	2
M, MS, N^1, N^2, N^1S, N^2S, MN^1, MN^2, MN^1S, MN^2S	10
P^1, P^2, P^1P^2, P −	4
C, C^u, C^w, c^v, c, CC^u, CC^w, Cc^v, Cc, C^uC^w, C^uc^v, C^uc, C^wc^v, C^wc, c^vc	15
D, D^u, d, DD^u, Dd, D^ud	6
E, Ee, e	3
Kell +, Kell −	2
Lewis +, Lewis −	2
Lutheran +, Lutheran −	2
Levay +, Levay −	2
8 × 2 × 10 × 4 × 15 × 6 × 3 × 2 × 2 × 2 × 2 =	2,764,800

Some of the groups are common in the population, others rare. Moreover, the proportions of the various groups differ from population to population. The antiserums for determining the groups are not all equally readily available, and probably no one laboratory has ever had all the antiserums available at any one time. Nevertheless, it would be possible for me to take a drop of blood from each of hundreds of individuals and, with the proper antiserums, to classify each person in one or another of these many blood groups. It would be surprising if any two of them fell into the same groups. Then, ten years from now we could all meet, say, in a reunion, and I could again take a drop of blood from each person. Without labeling the samples at all, and merely by referring to my previous list, I could identify the blood of each person, except for such duplications of type as might occur.

Another source of human individuality lies in the enzymes and enzyme systems that characterize us. Modern biochemical research indicates that metabolism proceeds by a series of chemical steps, each activated by a specific enzyme. All these enzymes are, as a rule, produced by each individual. Now and then an individual is found who fails to produce a particular enzyme, and as a result some metabolic process is interfered with at that point. The outcome may be the excretion of some unusual metabolite in the urine, or it may be evidenced by lack of pigmentation in the hair or skin, or by physical or mental peculiarity. In such instances the failure to produce the enzyme has been shown to be the result of a single gene substitution. Ancillary investigations on *Neurospora* are providing evidence of a one-to-one correspondence between gene and enzyme; and, in fact, this one-to-one correspondence may very well apply equally to gene and antigen and to gene and hormone.

II

Let us consider four human traits that at first glance seem to have no close connections with one another, but which turn out to be very closely related chemically. The four traits are albinism, in which there is an absence of pigment in skin and hair; phenylketonuria, in which there is severe mental defect accompanied by the daily excretion of about a gram of phenylpyruvic acid in the urine; tyrosinosis, in which tyrosine is excreted in the urine; and alcaptonuria, in which the urine turns black on exposure, because of the excretion of homogentisic acid, and pigment deposits are sometimes made in the cartilages and joints.

Each of these conditions appears to be due to a separate recessive gene. A long series of biochemical investigations shows that they are all intimately related to the metabolism of phenylalanine. Each recessive gene results in the failure to produce a specific enzyme which is produced by its normal allele, and when the mutant gene is present in homozygous form the metabolic process is stopped at that point, often with the excretion of the blocked product into the urine. When the recessive gene for albinism is present in double dose there is a failure to produce the enzyme formed by its normal allele and necessary to build melanin from its precursor, "dopa": when the mutant gene for phenylketonuria is present in homozygous form there is a failure to produce the enzyme formed by its normal allele and necessary for the degradation of phenylalanine; similarly, the gene for tyrosinosis and the gene for alcaptonuria cause failures in other stages of the normal metabolic process.

Thus these four metabolic derangements are seen to be chemically related and intimately bound up with the metabolic processes of the body. In a similar way glycogen disease, also due to a recessive gene, appears to be brought about as a result of the failure of this gene to produce the normal enzyme phosphorylase necessary to degrade glycogen into glucose-1-phosphate and so to glucose.

Human individuals show many other genetic variations in normal metabolic processes, many of them resulting in severe diseases. The detailed chemistry has not been worked out for all of them. Such inherited metabolic derangements as amaurotic idiocy, gargoylism, Gaucher's anemia, Niemann Pick's disease, xanthoma tuberosum, gout, and diabetes offer great possibilities for discovering the detailed chemical activities of genes. It is not too much to hope that someday the genetic basis for the complete metabolic processes of man may be built into a single mosaic. Indeed, the workers in at least one laboratory are already actively searching for variations in the normal metabolic activity of man, with gratifying results. Even at this early stage of the game it seems certain that each individual inherits a unique metabolic pattern, which can be measured and demonstrated.

Since several of these single-gene metabolic derangements, such as phenylketonuria and amaurotic idiocy, involve severe mental defects, it is well within the range of possibility that, through the intensive study of metabolic processes associated with mutant genes, the entire nervous and mental make-up of an individual may someday be specified in terms of measurable metabolic activities. Recent work with the electroencephalograph in measuring cerebral dysrhythmia indicates that this dysfunction is associated with the tendency to convulsive disease and is apparently inherited as a dominant factor. It remains for the detailed metabolism to be worked out.

The recognition of the genetic basis for many of the mental derangements has had to await the development of specific genetic methods. Indeed, the whole modern study of human individuality has required the elaboration of new and special methods. In so far as the analysis concerns genetic variability, the new methods center around two major approaches: gene-frequency analyses and twin methods. The gene-frequency procedures, which I have had occasion to formulate and elaborate on many other occasions, are used in the analysis of those traits in which genetic diversity provides the effective variable, and environmental diversity produces relatively little effect. The twin methods, which are becoming more and more essential in studies of human individuality, are used primarily in the investigation of those traits in the production of which there is reason to suppose that environment acts as an effective variable.

It has long been realized that there are two types of human twins: monozygotic, arising from a single fertilized ovum, which early in development has split into two parts; and dizygotic, resulting from two separate ova, which have matured and have been fertilized at the same time. The members of a pair of monozygotic twins are always of the same sex, and carry identical complements of genes. Differences between them must be attributed to environmental influences, including prenatal. Dizygotic twins, on the other hand, may be like-sexed or opposite-sexed, and the gene complements of the members of a pair will be in general of the same degree of similarity as those of ordinary brothers and sisters.

Many investigators have used the comparison of the two types of twins as a method of evaluating the relative contributions of heredity and environment in the production of various human traits, both normal and pathological. Recent refinements of the procedures, notably the twin-family method, have provided important evidence for the genetic basis of specific disease entities, physical and mental, as well as of basically uniform patterns in the organization or disorganization of physical and mental capacities essential in effort tolerance, personality integration, and intellectual performance. The twin-family method involves an extension of the comparison of twins to include not only monozygotic and dizygotic pairs, but also their full-siblings, half-siblings, step-siblings, and marriage partners. Long-term, extensive studies of this sort may be expected to provide information of the most important kind on human individuality. The interaction of genetic and environmental factors has already been thoroughly studied by this method in relation to schizophrenia, tuberculosis, and significant variations in intelligence, aging, and longevity, and there can be little doubt of the important part played by variable genetic factors in the development of these phenomena. It has also been indicated by experimental studies of animal behavior that the genetic determination of behavior may extend to very intricate and precise coordinative processes.

Human beings differ in their taste responses to various substances. These responses show a clear dichotomy in some instances, such as the ability or lack of ability to taste phenyl-thio-carbamide or mercapto-benzo-selenozol, and the responses are inherited in a simple manner. In other instances, such as the threshold responses to various substances such as NaCl and HCl, there is continuous gradation and high variability.

A long series of inherited variations in the blood is known, including differences in the serum, and in the shape, size, structure, and function of the various kinds of blood cells. Many of these variations result in clinical manifestations of greater or less severity.

In fact, no system of the body is without its genetic differences. The precise genetic nature of some of them is known, but for others the individual genes concerned remain to be specified. More than 100 mutations are known affecting the development and functioning of the eye, and many genes have been described having effects on the muscles, the nerves, the glands, the skin, the hair, the teeth, and the nails.

III

Man is a gregarious animal and tends to cluster in groups. The analysis of human genetic individuality is essentially a study of population genetics. Although the geneticist does not like the term race, with its implication of essential intraracial similarity and interracial difference, of "superiority" of one race and "inferiority" of another, nevertheless he realizes that human individuals do occur in populations, which may differ one from the other. Within any population there is considerable variability, giving each human being his own individuality. This individuality must be described in terms of the presence or absence of various alleles, plus the appropriate results of the exigencies of the environment to which the individual has been exposed. In addition to the description of the individual human being, however, the geneticist must describe *populations*. These are best characterized in terms of the relative proportions of the alleles, and of the results of the over-all environmental impacts.

Human populations differ genetically one from the other almost entirely in the varying *proportions* of the alleles of the various sets, and not in the *kinds* of alleles they contain. In all the instances extensively studied, it appears likely that no large population completely lacks any allele, but that one population may have a larger or smaller proportion of a given allele than another.

By special genetic methods it is possible to derive from the proportions of the various phenotypes in any population the relative proportions of the alleles producing these phenotypes. The genetic description of a population would then be the detailed listing of these proportions for the various alleles of all sets that have been identified and analyzed for the population. This type of description is as yet in its infancy for the human race, but its accomplishment is an urgent necessity for the understanding of human individuality. It is gratifying to note that this viewpoint is being adopted by physical anthropologists.

Since the genetic individuality of any human being is a function of the family and of the population to which he belongs, the principles of both Mendelian genetics and population genetics must be taken into account in its analysis. The principles of Mendelian genetics are now household commonplaces, but the principles of population genetics are not so widely understood. I have recently had occasion to organize these principles, and they might well be summarized at this point.

1. In a large population, with negligible or balancing effects of mutation, selection, and genetic drift, the proportions of the alleles of any set will remain constant from generation to generation. Under a system of random mating, the proportions of the genotypes formed by these alleles will likewise remain constant in the equilibrium ratio.
2. Under certain specifiable conditions, mutations and selection can change the proportions of the alleles in a predictable manner.
3. Classical Mendelian ratios are not necessarily to be expected among the pooled offspring of a series of families where the parental mating types are phenotypically identical.
4. Although classical Mendelian ratios are not to be expected in combined family data, nevertheless predictable ratios do occur. These ratios are population ratios, and are expressed in terms of gene proportions. Thus, where a common Mendelian ratio is ¾ : ¼, an equally common and analogous population ratio is $\frac{1 + 2q}{(1 + q)^2} : \frac{q^2}{(1 + q)^2}$, where q represents the proportion of the recessive allele in the population.
5. The analysis of population ratios may serve as a means of estimating the number and kinds of genes in a population, just as the analysis of Mendelian ratios may serve as a means of estimating the number and kinds of genes involved in a laboratory experiment.

In closing let me attempt to illustrate by concrete examples an arrangement of human variations in an order of increasing importance of heredity as an effective variable.

At one extreme of such an arrangement we might place such a trait as the language spoken by an individual. The particular language used, and the accent with which it is spoken, are probably almost entirely due to the environment in which the individual is brought up, and are little if at all affected by his genetic make-up.

Going one step further, I will call to your attention a case recently given me by a physician who had been a student in one of my classes in medical genetics. A man of fifty-one years was admitted to a hospital with symptoms of extreme breathlessness. It was noted that he had clubbed fingers, and this combination of symptoms caused the probability of severe cardiac disease to leap to the minds of the examining physicians. After extensive studies no such pathology could be demonstrated, however. On at least three previous occasions the patient had been told by examining physicians that he had serious heart disease, and on two occasions he was refused lucrative employment following the diagnosis.

Recalling his training in medical genetics, the physician asked the patient if anyone else in his family had clubbed fingers. The patient replied that his father had them, as did two of his five children. The final and correct diagnosis of this case was that the patient had inherited clubbed fingers, and that after being told so often by doctors, on the basis of this trait, that he had serious heart disease, he had developed an almost incapacitating anxiety reaction.

This case is obviously one where the trait is environmentally conditioned, but results indirectly from the presence of a genetic factor.

Going another step, we may consider a trait that is also environmental, but which results directly from the presence of a genetic factor. I refer to erythroblastosis, or hemolytic disease of the newborn. Here the condition is brought about by a chain of reactions, involving the inheritance in the embryo of an antigen present in the father but lacking in the mother, followed by the immunization of the mother by the antigen of the embryo, and the subsequent effect on the erythrocytes of the fetus, or later similar fetuses, of the maternal immune antibody.

The lines upon the fingertips, which account for much of the popular conception of human individuality, are the result of the interaction of both genetic and environmental influences. The similarity of fingerprints increases as the closeness of blood relationship increases, but the fortuitous stretching of the skin during embryonic development prevents them from ever becoming identical in any two persons. Likewise, many pathological conditions such as diphtheria, tuberculosis, cancer, and schizophrenia, in which both a genetic susceptibility and an environmental impact or infectious agent are required for their manifestation, illustrate traits that are obviously the result of both hereditary and environmental variables. Finally, we may point to such traits as the blood groups or the color of the eyes, in which genetic diversity appears to be the only effective variable, and in the variation of which environmental diversity seems to play no role.

Many and diverse are the modes of interaction between hereditary and environmental influences. And many and diverse are the resulting measurable human traits. The manifold combinations of these traits result in the almost infinite diversity of human individuality, a diversity we are just beginning to comprehend.

25

Race and Intelligence

DIANA TEAD

Whenever we wish to make comparisons between groups, such as between races, we must consider very carefully the range of individual differences within each of the groups under study. As a rule, differences between individuals are much more impressive than are differences between groups, as Miss Tead points out. She mentions the interaction of heredity and environment in producing individuality and describes the logic of the twin method which has been used widely to study these factors. The selection includes a good explanation of how other investigative techniques may be used profitably when the experimental method proves impractical.

Diana Tead is a graduate of Smith College and served for four years on the staff of the Communications Section, UNESCO, in Paris. The short article below is a chapter in the booklet *What Is Race?* (pp. 54–59), published by UNESCO, Department of Mass Communications, and distributed in the United States through UNESCO Publications Center, 475 Fifth Avenue, New York 17, N.Y. (a division of National Agency for International Publications, Inc.).

What is it that makes us intelligent? Is it what we have inherited from our parents, grandparents, and other ancestors of our race? Or is it the way we are brought up? In other words, is it heredity or environment?

Obviously, it is difficult to measure, because there is still no way to test a child at birth. Even before birth and, of course, immediately after, the environment, which means food, warmth, love, etc., begins to be a factor in our lives.

Rather than try to decide whether heredity or environment is more important, we should try to understand how both work together to determine the physical, as well as mental, peculiarities of a human being. A baby comes into the world with the physical beginnings his parents have passed on to him through the genes. From these beginnings the new individual develops by taking n food. Whatever he takes in he converts into his own particular kind of substance. Food is not only made into a human being, it is made into a particular kind of person.

The same food that is converted into a blond, blue-eyed, tall man who gets hay fever every August, is converted in his sister into a dark, brown-eyed, short person with no tendency to have hay fever. These differences depend upon the inside directors, the genes, which determine how the body shall utilize its food and energy. In the brother and sister some of the genes are different. Each has inherited a different pattern of genes.

In spite of the fact that under certain conditions the brother and sister differ in complexion, one being light and the one dark, under other environmental conditions this may not be so. Let the sister spend a long illness in a hospital away from the sunlight, and let the brother work every day in the bright sun. The skin colour of one will become pale and the other will darken. The difference we first saw depends both upon genes and upon the sun. The difference between the brother and sister is not only in being blond and brunette, it is a difference of responsiveness. The internal directors or genes do not settle the differences in an absolute way, but they determine how the body will react to something in the environment.

In the case of eye colour, the difference between brown and blue is settled by the genes before birth and we know of no environmental difference which will change it. On the other hand, the response which the brother expresses by sneezing and having a running nose, the symptoms of hay fever, can be avoided by keeping him away from certain plants or foods. Under these conditions, in the absence of such plants or foods, we should not know he was different from his sister, who, no matter what the environment, does not show this sensitivity. His heredity decides his reaction to a particular part of his environment, and in many cases this reaction can be changed by changing the environment. What we inherit then is a set of potentialities.

This is true of mental potentialities as well as physical ones. To show how heredity and environment inter-act on our mental capacities, we can make a comparison of two kinds of twins. Whenever two babies are born at once, one of two things has happened. Either two eggs, which happened to be present instead of the usual one, were fertilized by two sperms and two individuals were born at the same time, or one egg, after fertilization by one sperm, separated into two parts and each part became one of the twins. The first is like the birth of ordinary brothers and sisters, except for being born at the same time; the second is like the production of two copies of one person.

The difference is important, because ordinary brothers and sisters coming from different eggs and sperms may get different genes, while two individuals arising from a single egg and sperm have exactly the same genes. Any differences between one-egg twins, therefore, cannot be due to heredity. As we should expect, the scores on intelligence tests of one-egg twins are usually close, if not exact, while those of two-egg twins may be quite far apart. There have been cases, however, where for some reason one-egg twins have been separated at birth, one being brought up in a city atmosphere and the other in a rural atmosphere. In these cases, the scores on the intelligence tests were consistently higher for the city twins than for the country twins. This does not mean, of course, that the city twin was more intelligent, but that the tests, as designed, measured the kind of knowledge which is more accessible to a child in a city environment than in a rural one.

To get a fair picture of how races compare in intelligence as measured by tests, we must look at the results of tests taken in the same environment. New York City provides an interesting example. When the education authorities of that city decided to set up a special school for promising children, 500 gifted children were selected on the basis of intelligence tests given in elementary schools throughout the city. When these 500 children were examined as to race, religious and national backgrounds, it appeared that the distribution was approximately the same as that of the population of New York City as a whole, that is, about 10 per cent of the 500 were Negro children, corresponding to the 10 per cent Negro population at large. The same proportions were true for Jews and for some national groups. A curious observation, however, was that the great majority of these children (Negro, German, Jewish and Polish) were rather heavier in weight and larger in size than the other children of the same ages taken at random from the general population.

We do not know why this association between physical factors and mental ones exist, but it would seem to indicate that a favourable environment, in addition to the factor of innate ability, will have a good effect on both the physical and the mental development of children.

In any case we can see from this study that there is a wide range of intellectual ability within each racial, religious and national group. Other tests measuring purely racial differences have pointed to the same conclusion. In the United States, some groups of Northern Negro recruits, when tested by the Army during World War I, were found to be superior to some groups of Whites.

This simply means that when either group, Negro or White, is placed in a superior economic and educational environment, the average score on mental tests tends to rise; when either group lives in an inferior economic and educational environment, the scores tend to remain low.

Even more than with physical traits, there is a great deal of overlapping among the races. Or, put in another way, the difference among individuals in the same race is greater than the difference between the averages of any two races.

We know that there are exceptional individuals in each race — one of the brightest children ever tested was a Negro girl of nine years with an IQ (Intelligence Quotient) of 200, twice that of the average child. Whether the percentage of gifted persons is higher in some races than others still cannot be proved. Nor is there conclusive proof that hereditary mental defects are more frequent in any one race. These tragic occurrences seem to be fairly evenly distributed among all peoples of the world.

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Are the Sexes Really Equal?

LEONARD CARMICHAEL

As with the comparisons of races, in any comparison of male and female traits allowance must be made for wide variations. Dr. Carmichael has this in mind when he reminds the reader not to jump to conclusions when making comparisons of individual females with individual males. In this article the author surveys the whole question of differences between the sexes, including biological, developmental, physical, intellectual and emotional, and differences in the way males and females are treated by society.

Dr. Carmichael is now administrative director of the Smithsonian Institution, the nation's oldest, full-time research organization. He is also a psychologist with interests in several areas of research and teaching which he engaged in at Princeton, Brown, Rochester, and Tufts (where he was also president). The selection below is from his *Basic Psychology*, published by Random House, Inc., as condensed in *Science Digest*, October, 1957 (pp. 38–43). Permission to reprint has been granted by the author, Random House, and *Science Digest*.

There are differences between the male and the female not only in bodily structure but also in mental life.

One basic question is to determine how much of the observed difference between men and women is attributable to sex characteristics that are biologically based, and how much the sex differences that appear in any society are the result of learning and cultural indoctrination.

Geneticists have shown that the chromosome patterns of men and women, and indeed of male and female animals generally, are not the same.

In the human being at the time of conception sex differentiation is found in 1 of the 48 chromosomes that are characteristic of the human species.

If the fertilized cell is to become a male, it has an "X" chromosome and a small "Y" sex chromosome.

If it is to become a female, it has two large "X" chromosomes instead of an "X" and a "Y." The other chromosomes are similar in both sexes. Biologists have concluded that it is the absence of a full second "X" chromosome and not the presence of a "Y" chromosome that is decisive in determining sex.

It is not only in the germ cell at the beginning of life that the differences between a male and female organism are found in the chromosome pattern. The difference in sex chromosomes is repeated in all cell divisions and cell differentiations that take place as the organism progresses toward adult life.

To put this in another way: The chromosomal pattern of all the cells that make up the living body of an adult male is different from the chromosomal pattern of the adult female in their "X" and "Y" chromosome patterns.

MORE BOY BABIES

It is customary to think of human populations as being equally divided between men and women. Statistics show, however, that there are many sex differences in society. For example, 105.5 male babies are born in a country such as ours, to every 100 females.

On the other hand, in America and other civilized countries, more boy infants die than do girl infants. The proportionate excess of male infant deaths over female infant deaths in the United States is about 27 percent.

Some statistical differences persist into later life. There is a sex difference in suicides. The number of suicides in proportion to the population is remarkably constant in the United States from year to year. Less than one-third of suicides are women. This fact suggests that even though there seems to be evidence that women are more emotional in certain respects than are men they do not seem so apt to carry emotionality to the point of self-destruction.

It is apparently true that more boy babies are born after wars than is usual. This may be due to the fact that in war-time more younger people marry, or to war-time shifts in diet.

As prenatal development progresses, differentiation between the male and female fetus can be discerned. These differences are related to sex organs and also to the glands of internal secretion and, in a more subtle way, to the whole proportion and size of every bodily structure.

GIRLS DEVELOP FASTER

In many respects, girls develop more rapidly than do boys. For example, in the period from birth to adolescence, the ossification — that is, the hardening — of bones takes place on the average months earlier in girls than in boys. Part of the pelvic girdle in girls becomes ossified on the average by 13 years and 2 months.

This same part of the skeleton in boys is not on the average hardened into adult bone until 15 years. Permanent teeth appear earlier in girls than in boys. It is true that men on the average are taller than women, but at age 13 girls, surprisingly enough, are about three-quarters of an inch taller on the average than boys.

On the average, boy babies are a little slower in beginning to talk than are girl babies. If social and other factors are held constant, it also seems that in the early developmental years sentences used by little girls are longer than those used by little boys. Probably at all times the average total vocabulary of the female of the species exceeds that of the male.

In comparison with men, women seem to accomplish their best work in areas requiring verbal skill. In a list of 20 outstanding women more than half attained renown in literature. Maybe there is a biological reason and statistical evidence for all the overworked jokes about women being the verbal sex.

The question as to whether or not there are innate "instincts" peculiar to each sex has long been discussed by psychologists and students of human nature. In the older literature it was often taught as a fact that what was called the "parental instinct" was stronger in women than in men.

Similarly the fighting instinct was considered to be stronger in men than in women.

In recent years, an effort has been made to explain some of the differences of this sort in terms of culture and training. The idea that there is a biological basis for some of these distinctions, overlaid though they may be by training, still has not been wholly abandoned.

In considering whether or not sex attitudes are biologically or socially determined, some studies of chimpanzees seem to indicate that infant male chimpanzees are more aggressive and less well-behaved than female chimpanzee infants.

Male chimpanzees are said to be more prone to run away. It is reported by animal trainers that female chimpanzees are more willing to work with their hands, to learn to thread a needle, and so forth.

Boy chimps are often indifferent to clothing and tend to be destructive. Female chimps are more willing than boys to learn to dress and undress themselves, and indeed these girl animals show some indication of enjoying clothing.

WHICH SEX IS SMARTER?

Special attention has been given to the question as to whether or not there are differences in "general intelligence" between men and women when good modern intelligence tests are used on unselected populations, including all appropriate ages. The answer seems to be that no differences in general intelligence between the two sexes has been demonstrated.

In children up to adolescence, girls may exceed boys by a few points of IQ. This is not surprising, because we have seen that in almost all of the measured physical indices of development, girls develop more rapidly.

Studies have been made of unusually gifted children. In a famous investigation conducted by Lewis M. Terman of Stanford University, 1500 children were selected from large groups having an equal number of boys and girls. It was decided that only children with an intelligence quotient of 132 or above would be chosen for further study.

When this group was selected about 120 boys for every 100 girls were found to qualify for entrance into the superior class. This result was unexpected. Very careful study was made of the techniques used in selection, but no hint was found of any selective procedure which favored males.

This last conclusion seems to support the idea long ago advanced by the great English statistician, Karl Pearson, that men are the more variable sex. Not only do there seem to be more superior male children as measured by intelligence tests, but records also indicate that there are more males in institutions for the feebleminded and defective than there are females.

FIGHTING AND COOKING

Anthropologists have studied the proportionate division of labor in a great variety of tribes and social groups throughout the world. In one such study, which involved 224 representative tribes, it was found that fighting in the sense of participation in warfare was always almost exclusively a male occupation. Similarly it was found that more than 90 percent of the cooking was done by the women.

Almost all metal-working of the world, no matter in what society, is done by men. A large part of the manufacture of clothing, however, is done by women. Similarly, men are predominant in hunting and fishing, whereas women do most of the pottery making.

Among primitive people and civilized people the priesthood and the other learned professions

— that is, the astrologers, judges, scribes, historians — are predominantly men. There is some evidence, however, that the earliest doctors were women. It seems possible on the basis of studies of primitive society that women, in searching for food and in tending fires and cooking, first hit upon the medicinal values of roots and herbs.

In some primitive societies women actually tend the sick, but men play the part of witch doctors and "medicine men."

So far as works of genius in the arts, sciences and letters are concerned, men seem to have been much more commonly acclaimed as outstanding than women. No sure answer as to why this should be has ever been given. Many biological and psychological theories have been developed to attempt to account for the fact that genius seems to be so largely a male characteristic.

Women who resent this judgment, however, still claim that if society were differently constituted, and opportunities more equal, genius would be more evenly divided between the sexes than it has been in the past.

The fact that intelligence, as measured by present-day tests, seems to be equal in the population for men and women, seems to lend support to this feminist view. In our society there is a growing tendency to provide equality of opportunity and equality of compensation for both men and women. This may ultimately lead to the discovery of more women of genius than in the past.

In general, it seems that women are somewhat more inclined to have accidents than are men. It is often said that this is not true in automobile driving. In a study of taxicab drivers, however, when mileage was equated, women had almost three times as many accidents as men.

CONSIDER THE INDIVIDUAL

Other studies bear out the fact that women are more accident-prone than men. Here as in all other cases, individual differences transcend sex differences. That is, some men are more accident-prone than some women. There is much evidence that suggests that regardless of sex some people are much more likely to have repeated accidents than are others.

No final conclusions can be drawn as to how much sex differences are due to inborn anatomical, physiological and psychological characteristics and how much these differences are due to social learning.

There seems little doubt that in intellectual ability, as usually measured, the two sexes are on the average about equal.

The same, however, cannot be said with assurance about motives, emotions or physical skill.

Finally, however, the individual must be considered and measured for himself or herself. Individuals should not be assigned a higher or lower capacity just because of maleness or femaleness. Some women can pitch a baseball much better than some men, and some men can take care of a baby better than some women.

27

Facts About Mental Deficiency

L. N. YEPSEN

Throughout the United States attention is being given to the problem of the mentally retarded and the mentally deficient as never before. Despite the relatively small size of this deviant group, it represents one of the most demanding social problems of our time. Psychologists have pioneered in the scientific study and the professional care of the retarded child. This selection presents the questions most often asked about mental deficiency — and their answers — as stated in a booklet on the subject by

Dr. L. N. Yepsen. Causal factors, nature of retardation, care and treatment, training, and the social problem are covered in these twenty-five questions and answers.

The late Dr. Yepsen was a clinical psychologist for the Department of Institutions and Agencies of New Jersey. He was a Diplomate of the American Board of Examiners in Professional Psychology. The article below, as condensed in *Science Digest* for May, 1956 (pp. 81–85), is reprinted by permission of the publisher.

Mental deficiency is the second largest social problem in the United States today. Within the category of mental deficiency are more than 1½ million persons, ranging from the severely retarded to those whose deficiency becomes apparent only in special situations.

But despite the size and social significance of the problem, there is much general misunderstanding about mental deficiency. L. N. Yepsen, Ph.D., and the New Jersey State Department of Institutions and Agencies, set out in a recent booklet to separate fact from fancy in the field of mental deficiency. The following true and false statements taken from the booklet, should give the reader a better understanding of this social problem:

1. *As a baby, first evidences of mental retardation are that the child is slow to notice things, slow to sit up unsupported, retarded in walking and talking.*

A. True. The delay in one of these accomplishments may not be an indication of retardation, but a delay in two or more is usually found to be characteristic of children who are mentally retarded.

2. *About one out of every hundred of the population is mentally deficient.*

A. True. This is the figure generally accepted by competent authorities in the field, although the percentage in the new-born may be somewhat higher. One must be careful to differentiate between simple mental retardation and mental deficiency. The mentally retarded are those who may succeed in home, school and community life without supervision, if special training is given. The mentally deficient require supervision even though they are given special training.

3. *Mental deficiency and mental illness are not the same.*

A. True. Mental deficiency is a lack of mental development; in mental illness there is a disturbance in functioning. In mental deficiency the individual never had the potentialities for normal mental growth and development. In mental illness the individual's mental growth and development may have been normal but the manner in which the mentality operates is peculiar, different, bizarre.

4. *At least 90 percent of mental deficiency is due to poor heredity.*

A. False. This is an entirely mistaken notion. It is more likely that less than 50 percent of mental deficiency is due to heredity. A considerable proportion of the non-hereditary cases are due to a variety of causes, some of which are obscure or extremely difficult to identify.

5. *In some cases the severely retarded child may be recognized at an early age.*

A. True. The severely retarded child is sometimes recognized at birth or shortly thereafter because he fails to respond to the usual stimuli in his environment as does a normal baby. The growth factor is an important one in diagnosing mental deficiency.

6. *Mental deficiency may not be recognized in some cases until the child fails to learn in school.*

A. True. This is particularly true of the mentally retarded and the high-grade mentally deficient child. His development may not have appeared to have been unusually retarded as a pre-school child, but in the school situation one of the primary results of mental deficiency — the lowered ability to learn — quickly identifies him as a slow learner. All slow-learning children should be studied by the psychologist. The psychologist will be alert to refer the child to other competent specialists as needed.

7. *Most mentally deficient children have pleasant dispositions.*

A. True. Anyone who has ever worked in an institution or school for the mentally deficient knows this to be true. The child becomes irritable and difficult to manage when he becomes frustrated in a complex and highly competitive environment, whether it be in the home, in the school or in the community.

8. *All mentally deficient persons should be in institutions.*

A. False. This is not true at all because many can and do perform very useful services in the community. Residential training schools should be only for those who are placed there because of (a) the need for special training which unfortunately is not provided in their home community, (b) for their own protection or the protection of others, (c) because of the great amount of physical care which is required, or (d) when the presence of the mentally deficient person disturbs the economic or emotional balance of the home.

9. *Marriage of cousins is one of the main causes of mental deficiency.*

A. False. Consanguinity is no longer considered to be one of the main causes of mental deficiency. If the cousins are of normal stock, the offspring should be normal but, of course, if the cousins are of poor stock, then it is probable that the offspring might be subnormal.

10. *Mental deficiency is rarely caused by a child's falling on its head.*

A. True. A fall, or other head injury, is frequently given as a cause for a child's mental retardation. But the normal head injuries of childhood rarely cause severe damage to the brain.

11. *Some types of mental deficiency are the result of severe illnesses in infancy which damage the brain.*

A. True. There is evidence to show that certain illnesses, particularly those in which there is a high fever, damage the brain tissue, which results in a reduction of the potentialities for the person's normal mental growth.

12. *You can always tell whether a person is mentally deficient or not by taking a look at the size of his head.*

A. False. Only in the case of the very, very small (microcephalic) or very, very large (macrocephalic and hydrocephalic) head, the size of it doesn't mean a thing as far as being diagnostic is concerned. Even in such instances there are rare cases in which there are but limited deficiencies.

13. *All mentally deficient persons are dangerous to the community.*

A. False. A mentally deficient person is not a potentially dangerous one.

14. *Many mentally deficient persons can be trained to be self-supporting citizens.*

A. True. Their social and economic adjustment may not be at a high level but many of them need not be totally dependent upon the community. There are thousands of mentally deficient persons in the community who are successful graduates of classes for the mentally subnormal and the state training schools for the mentally deficient.

15. *Mental deficiency can be cured.*

A. False. There is absolutely no evidence that mental deficiency can be cured. In the light of today's knowledge there is no known medical treatment or training program which can give a truly mentally deficient individual normal intelligence or enable him to function at a normal level. Training and treatment will, however, help him to reach his full potential and permit him to accomplish many things he would not otherwise be able to accomplish without such training.

16. *Some mentally deficient persons can do certain jobs which require patience and manual dexterity.*

A. True. This is one of the saving characteristics of the mentally deficient individual. If properly trained and properly motivated on the job, he will not tire of routine tasks, although he welcomes a change as much as does his normal brother. His manual dexterity, however, is not a dexterity of the fine muscles; but as a result of proper training, he may become able to coordinate his large muscles quite well.

17. *A mentally deficient child is not capable of loving its parents.*

A. False. The mentally deficient child responds to love and affection perhaps even more than does the normal child. His is primarily an emotional and not an intellectual life.

18. *Mentally deficient children need specialized training, not merely a "watered down" regular course of study.*

A. True. The most successful training programs are those which are devised to meet the individual and particular needs of the mentally deficient child. The program should be one essentially of "clinical teaching." The mentally deficient child is an outstandingly slow learner and, therefore, must have the material presented to him at the moment which is psychologically appropriate in steps which are small. Small steps provide for the elimination of gaps in the teaching process. All learning must be highly motivated.

19. *Gland-extract treatment can make a mentally deficient child normal.*

A. False. Unfortunately, from time to time, this claim has been made. Except for occasional changes in the body structure of clinical types such as the cretins, the best authorities agree that not much benefit can be expected from endocrine treatment. As yet, the field is definitely limited and until additional research studies are made, this must remain one of the many unlocked doors.

20. *There are just as many mentally deficient girls as there are mentally deficient boys.*

A. True. This may be controversial but there is no evidence to support the point of view that there is any difference in the sexes as far as the percentage of mental deficiency is concerned.

21. *Fifty percent of all persons are below the national average in intelligence.*

A. True. Some persons do not recognize that the average is the mid-point above which and below which lie 50 percent of the population.

22. *More than one half of those who commit offenses against society are mentally deficient.*

A. False. A study of 32,000 admissions, covering an 18-year period, to penal and correctional institutions as well as training schools for the juvenile delinquents, revealed that but 9 percent were mentally deficient.

23. *Parents of a mentally deficient child should decide not to have more children.*

A. False. The shock of having a child who is mentally handicapped, born to them, is a terrific one to all parents. The birth of such a child may easily cause some parents to decide not to risk any more children. They should consult their physician to determine if there is the possibility that they cannot bear normal children.

24. *Of the probable 1,600,000 mentally deficient persons of all ages in the United States less than 10 percent are in state residential schools for mentally deficient.*

A. True. The figure is slightly less than 10 percent, somewhat under 120,000. It must be remembered, however, that the specialized institutions serve many more than this number for there is a steady movement of population with many of the trained individuals returning to the community each year.

25. *There is still much to be done to bring many state programs up to a high level.*

A. True. Each state should have a well planned and carefully integrated program if the needs of all are to be met. Such a program should include: Special classes in public schools for several types of retarded children, sheltered workshops, diagnostic and guidance clinics, job placement, industrial, farm and domestic colonies, family placement, specialized residential schools, both public and private, home training and continuous supervision.

28

Concerning the Nature and Nurture of Genius

SIDNEY L. PRESSEY

The facts about the mentally retarded were outlined in selection 27; the author of this selection is concerned with that equally rare and perhaps equally misunderstood individual — the precocious child. Like the retarded child, the precocious is different from the normal in degree, but not really in kind. Dr. Pressey emphasizes nurture as the critical determiner of superiority. Factors which appear to be especially important are motivation, encouragement, competition, and opportunity to learn. The author takes issue with some child psychologists in respect to the educational process for gifted children and makes specific recommendations for revision and extension of our educational services to encourage the development of talent.

Dr. Pressey has been professor of psychology at The Ohio State University for over thirty-five years. During much of this time he has been concerned with problems of the superior student. He is a Diplomate of the American Board of Examiners in Professional Psychology. This particular selection on encouragement of genius appeared in *Scientific Monthly* for September, 1955 (pp. 123–129), and is reprinted by permission of the publisher and the author.

It has been well said that "in the present international tug of war, survival itself may depend upon making the most effective use of the nation's intellectual resources" (*1*, p. 4). Means of better identifying young people of superior intellectual capacities, and of getting more of them into present programs of advanced training, have been widely discussed. However, there has been relatively little consideration of whether present educational programs are best suited to the needs of our most brilliant young people. Superior abilities are now generally considered so predominantly a product of innate constitution that certain "educational" factors, possibly of very great importance in the growth of such abilities, are overlooked. It is sometimes well to get outside of current habits of thought and try to look at a topic in a reappraising way. This paper attempts so to do. It focuses attention on that most extraordinary type of very superior intellect — the precocious genius — as possibly exhibiting especially clearly both innate capacities and developmental influences involved in extraordinary accomplishment. It presumes to suggest that there may be ways by which many more "geniuses" might be not only discovered but even, to a substantial degree, *made* and brought to fruition.

MAJOR FACTORS MAKING FOR PRECOCIOUS MARKED SUPERIORITY

An informal search for instances of marked precocity suggests that such cases have been especially frequent (or, at least, especially noted and featured) in certain fields and in certain localities at certain times. In the Europe of 100 to 200 years ago there were outstanding musicians of whom most were precocious. Handel played on the clavichord "when but an infant" and was composing by the age of 11. Haydn "played and composed at the age of 6." Mozart played the harpsichord at 3, was composing at 4, and was on a tour at 6. Chopin played in public at the age of 8; Liszt, at 9; Verdi, at 10; Schubert, at 12; and Rossini, at 14. Mendelssohn was playing publicly and also composing by the age of 9, as was Debussy at 11, Dvorak at 12, and Berlioz at 14. Wagner conducted one of his own compositions in public when he was 17 (*2*, *3*, *4*).

Recently, and especially in this country, there have been many precocious athletes. Thus, Bobby Jones was state golf champion at 14 (*5*). Marlene Bauer was playing notable golf at 13 (*6*). Sonja Henie was figure-skating champion of Norway at 10 and world champion at 15. Barbara Anne Scott was Canadian figure-skating champion at 15 (*7*). Vincent Richards was national tennis singles champion at 15, and Maureen Connolly was woman's singles champion at 16. Mell Ott was in big league baseball at 16; Feller, at 18. Eddie Lebaron was an intercollegiate football star at 16. Bob Mathias won an Olympic gold medal in track and field events at 17 (*5*). The reader may doubt whether athletic champions are relevant to the topic of this paper but he can hardly question that they are very competent in their fields. Moreover, precocity in athletics and in musical performance might seem especially extraordinary because finger reach and dexterity on a musical instrument and strength, as well as skill and endurance, in athletic competition would seem especially to call for physical maturity.

An especially remarkable type of athlete must also be noted: the champion whose superiority emerged after great and persistent efforts to overcome a crippling handicap. Walt Davis, holder of a world's record in the high jump, was a former polio victim (*8*). Glenn Cunningham, the Olympic runner, was burned so severely in the legs when he was 8 years old that it was doubted that he would ever walk again. At the age of 8, Nancy Merki had polio and at 10 was more paralyzed, but at 13 she was high-point scorer in a national swimming meet (*5*). Other well known athletes have had polio. In all these instances, the athletic prowess was the final result of very persistent (and usually expertly guided) efforts to overcome the handicap. There was no evidence before the injury or illness of notable athletic potential.

The first question, then, is why there should have been a rash of notable precocious musicians in the Europe of a century and more ago and a spate of youthful athletic champions in this country now. Certain major factors seem evident. In the Europe of that time, music was the major popular interest, reaching practically all social classes and all ages, and offering even to underprivileged youngsters the possibility of wide popular acclaim. Athletics is a similar interest in this country now. The second question is more specifically how, in such favorable total situations, have these prodigies come about. A study of their careers suggests that the following factors are important.

1. Precocious musicians and athletes usually had excellent early opportunities for the ability to develop and encouragement from family and friends. Mozart's father was a musician; his older sister was his companion in music; family and friends admired and encouraged the boy. Schubert's father was musical and fostered Franz's musical aptitude; soon Franz became a member of a string quartet with his father and two brothers. Of the athletes, Bobby Jones lived next to a golf course. When he was still a little boy, he was given small clubs and followed his father around the links. From early childhood, Barbara Anne Scott's skating was fostered by her father, and soon her whole life was so centered.

2. Usually individuals who developed precocious excellence had superior early and continuing individual guidance and instruction. From the age of 3, Mozart was taught, guided, and managed in his career by his father, who sought practically from the beginning to make his son an outstanding musician. Mendelssohn, also from the age of 3, was taught by his mother and other good musicians. Marlene Bauer's father, a golf professional, began to teach her the game when she was 3. Nancy Merki had an expert swimming coach.

3. Precocious individuals have had the opportunity frequently and continuingly to practice and extend their special ability and to progress as they were able. From the age of 3, Mozart practiced with his older sister; he had the opportunity to play the violin, the harpsichord, and the organ, to perform frequently in public, and a little later to conduct. From the age of 11, Maureen Connolly practiced tennis at least 3 hours a day. The climate of southern California made this possible at all seasons. She took on more able opponents and entered more important tournaments, as she was able. Nancy Merki was "in the water for hours at a time, just trying to master the trick of fluttering her legs." Under the guidance of her coach she moved forward in her aquatic accomplishments as she was ready.

4. The special precocious ability usually brought a close association with others in the field, which greatly fostered the abilities of all concerned, and led to a still wider stimulating acquaintance. Mozart lived from early childhood in a world of musicians who listened to and watched one another, played together, cooperated, competed, raised levels of aspiration, and were keen in criticism and encouragement. His musicianship brought acquaintance with the great all over Europe, including the Austrian emperor. Bobby Jones lived largely in a golfers' world, which developed his skills at the same time that he raised golfing standards and increased the popularity of the sport. His friendships have indeed been wide, including President Eisenhower.

5. As a result of many opportunities for real accomplishment, within his possibilities but of increasing challenge the precocious musician or athlete has had the stimulation of many and increasingly strong success experiences — and his world acclaimed these successes. It is well recognized that frequent failure and continued frustration may debilitate personality and competency, just as a disease does. But the opposite also seems true, although it is not generally appreciated: frequent, much-admired successes increase effort, build up psychosomatic vigor, make attempts more vigorous, and adequate, and better integrated, and build ability. The opinion is ventured that such "furtherance" is as important a phenomenon as frustration, and that systematic research regarding furtherance might well be as profitable as research on frustration has been.

At any age, development of any ability is fostered by a favorable immediate environment, expert instruction, frequent and progressive opportunities for the exercise of the ability, social facilitation, and frequent success experiences. Important advantages would seem to accrue from having these factors begin operation early. The physique may grow and adapt in congruence. As the young musician stretches out his hands and exercises needed muscles and coordinations, his skills may be not only learned but somewhat made part of his growth. This might be true, not for mechanical skills alone, but also for related integrations in the central nervous system, and for related percepts and concepts. So the precocious musicians played not only with skill but also with understanding, and they composed, notably and early. Possibly some integration of learning and growth might occur with abilities ess closely related to a skill. Any ability, developing early, might benefit by having the great energies of childhood and youth devoted to it. Also, the child in the grip of a strong interest (as a hobby) seems often single-mindedly absorbed in it to an extent less common later, when probems of social status, economic responsibility, or the other sex may distract. If an interest is already well established when adolescence comes, the energies of that period may pour into it.

The thesis thus is that, in attempting to account for notable precocity in such fields as music and athletics, too much stress has been put on presumed extreme constitutional genius and too little on a concomitance of favorable factors, operating in the growth years. Instances of great athletic skill emerging from efforts to overcome a seemingly crippling handicap seem to emphasize the potency of these last factors. Presumably, the original physical potentials of these individuals were good, although not manifest, before the handicap struck; but the great potential of favoring circumstances seems especially evident. In this connection, Wechsler's argument (9) may well be recalled — that the range of human physical traits, as in height, strength, and quickness, is really not great, and that the range in mental capacities may be less extreme than is usually supposed. Rather, superior original capacity, *growing under a favorable concomitance of circumstances*, develops into genius.

So far, the discussion has dealt primarily with outstanding precocious skills, in athletics and music. May the youthful organism not be capable of outstanding accomplishments more intellectual in nature? Here it should again be mentioned that notable musical performance would seem to involve keen musical understanding as well as dexterity (and outstanding athletic performance perhaps often involves more intelligence than is usually conceded). In youth, the famous precocious musicians not only performed but composed notably; and composing music is surely a highly intellectual activity.

But precocity has appeared in sundry other and clearly intellectual fields. John Stuart Mill began the study of Greek at 3. By the age of 8 he had read Xenophon, Herodotus, and Plato and had begun to study geometry and algebra. At 12 he began logic, reading Aristotle in the original. The next year he began the study of political economy; at 16 he was publishing controversial articles in that field (*10*). When he was 6 years old, John Ruskin wrote verse. Macaulay compiled a "universal history" at the age of 7. Published poems of William Blake, Thomas Chatterton, and Alexander Pope go back to their 12th years; poems of Robert Burns go back to his 14th year, and of Milton to his 15th year. Pascal wrote a treatise on acoustics when he was 12. Galileo made his famous observations of the swinging cathedral lamp when he was 17. Perkin discovered the first synthetic dye when he was 18 (*11*, pp. 198–219). Farnsworth, at 15, "evolved an electronic means of sending pictures through the air" (*12*). Recently, 11-year-old Italian Severino Guidi, 10-year-old Turkish Hasan Kaptan, and 11-year-old French Thierry Vaubourgoin have been mentioned (*13*) as precocious painters. Norbert Wiener has written his sensitive account of his own precocity: college entrance at 11, Harvard doctorate at 18 (*14*). However, as compared with music and athletics (*15*), precocity seems more rare in art, literature, and science, and especially so in this country. Why?

INFLUENCES HAMPERING THE PRECOCIOUS

There is a general belief, fostered in this country by most child psychologists and "progressive" educators during the past 25 years, that intellectual precocity is somehow not quite healthy, is almost always a hazard to good social adjustment, and should be slowed down rather than facilitated. In the home, the early-reading precocious child causes anxiety, in spite of the usualness of such precocity in Terman's gifted group and in biographies of famous men (*16*, *17*). The schools oppose entrance before the standard age of 6, in spite of the evidence, from some half-dozen experiments, that gifted tots admitted earlier have done well, both academically and adjustmentwise (*18*). The general public tends to regard the intellectually gifted small child as a freak. In short, there is usually none of the initial encouragement in the family, early fostering, and favorable general social climate that got many musical and athletic prodigies off to a flying start.

As a result of mass education and indifference to the needs of the gifted, there is almost none of the individualized guidance and instruction for excellence that was mentioned as an important element in the rapid development of precocity in music and athletics. A good music teacher is usually especially interested in finding and training pupils who are gifted musically. The athletic coach tries to find and bring to peak performance the ablest young athletes in his school. But the usual public school teacher does not have the time, the attitude, or the methods to do much, if anything, for another young Macaulay or Farnsworth in his classes.

In contrast to possibilities of continuing intensive practice and rapid progress in music or athletics, opportunities often are entirely lacking for a youngster to indulge intensively and continuingly an aptitude in such a field as a science, advancing as he is capable. A boy precociously interested in chemistry may have to await schoolwork in that subject until the regular course in his high-school junior year. He must then start and progress with his classmates, and in his senior year must take other subjects (intensive work in one field is frowned upon as interfering with a broad program) and not "hang around" the chemistry laboratory (*19*). Nor can the broadly gifted and precocious youngster advance in his total school program more rapidly than the average; acceleration is, in most schools, considered unwise.

Whereas the precocious young musician or athlete soon has an acceptance and a mounting status that is tremendously stimulating and educative for him, in musical or athletic groups — and these groups have status in school and community — the budding young scientist or scholar may be isolated or may associate only with a friend who is also considered "odd" or may belong only to an anemic subject club of no prestige in the community.

In contrast to the early and continuing successes of the young athlete or musician, possibly mounting to international acclaim, the young scholar or scientist may have no opportunities to make good except in class assignments and may obtain no evidence of success other than good marks. The teacher (perhaps made uncomfortable by keen questions) may even criticize his intense interest, and the other youngsters may call him sissy or odd. For him there is frustration, *not* the furtherance of cumulative success.

Suppose that Mozart or Bobby Jones had not been allowed to begin his music or his golf until the other children did, or to practice more or progress faster, or had had only the instruction of a school class in music or physical education. Suppose that they had been kept from playing with older children or adults in the fear that they might become socially maladjusted, kept from associating much with other musicians or golfers because that would be narrowing and undemocratic, kept from public performances or tournaments because that would be exploiting the poor child! It surely may be questioned whether they would then have reached the preeminence they did. Abuses in the afore-mentioned directions are, of course, possible. But it is also an abuse to withhold opportunities from precocious youngsters who are eager to advance and excel. The opinion is ventured that the last type of abuse is now, in this country, the more common one.

TOWARD MORE AND BETTER AMERICAN GENIUSES

The hypothesis thus is that a practicing genius is produced by giving a precocious able youngster early encouragement, intensive instruction, continuing opportunity as he advances, a congruent stimulating social life, and cumulative success experiences. In the instances given, however, the circumstances have all been so superior as to seem somewhat out of reach. Moreover, there was sometimes imbalance or exploitation. In the average college or school, what steps might be possible that would move with reasonable caution and good sense in the directions indicated here and perhaps somewhat benefit a great many youngsters as well as occasionally help toward the production of a "genius"? Two steps would seem feasible and of great possible fruitfulness.

The first proposal is that there should be, in a college or a school system, a person who might be given the somewhat colorless title of coordinator of special programs, lest the more precise label of personnel specialist for superior students cause them embarrassment and antagonize parents of students not selected or served by him. Such a person in a college should scan each entering student's record to find high-school valedictorians, science-fair winners, and others with evidence of superior ability. He should watch for such evidence especially among students in the freshman year. He might even follow reports on high-school science fairs and the like and recruit promising youngsters for his college in the manner of a football coach. (If other colleges object to this, maybe competition among colleges for the intellectually superior might be a good thing!) As he locates such cases he should seek them out, encourage them, and bring them to the attention of appropriate faculty members. He should try to help these students in any problems they have, find opportunities for them on campus, and perhaps arrange summer work or travel opportunities. He should make a special effort to bring congenial members of his group together and to foster stimulating companionship and morale.

He should see to it that his program receives publicity and that his youngsters receive recognition. He should guide and further any plans they have for professional or graduate training and for careers.

In a secondary school or school superintendent's office, a person similarly designated to find and foster the most able students would try to keep the elementary schools alert to discover especially bright children there. As these move on to high school, he could watch for them. He would have the high-school teachers inform him of outstanding students in their classes and keep alert for other evidences of talent, as in hobbies. He would become acquainted with all such youngsters, encourage them, and bring them into contact with appropriate teachers and into appropriate subject clubs or other groups. Educative trips with other youngsters might be ar-anged and perhaps summer work that would be both financially and educationally profitable. A ocal business or professional man might be en-isted to sponsor an outstanding youngster who needed such support. Contacts might be readied with a college or university.

If such guidance or personnel specialists for he most able were generally available in colleges and high schools or public school systems, it is believed that they could greatly increase the number of young people going into advanced raining, select them better, and greatly improve he effectiveness of their education (*20, 21*). Such a position might be only half time, for a tudent counselor or assistant principal, but it hould be seen as his distinctive opportunity. If n a college, he would work with the ablest students, the best teachers on the faculty, and the best professional and graduate schools. If in a econdary school, he would deal with the finest tudents and the community leaders most in-erested in young people. He would try cumu-atively to build community interest in and opportunities for these ablest young people, as hrough the local papers and service clubs. He would have mutually profitable relationships with the best colleges and universities. At regional and national meetings, as of guidance associations, these personnel workers at all levels would meet with others doing like work. Slowly, hey might change public attitudes to interest in he intellectually, as well as the athletically, able. Surely no position could be more finely rewarding.

It is not enough, however, to provide special student personnel or guidance service for superior students. *In proportion as they are very able and especially as they have special talents, special adaptations of the usual curriculums are likely to be desirable.* The able youngster not yet sure of his special interests may wish to explore very widely. Once he has found that interest he may, legitimately, wish to push it hard. Before long, his accomplishments may warrant his admission into courses ahead of his status. (The sophomore may desire some course not usually available before the junior year.) Soon, he may be ready for an independent project under supervision of one of the ablest teachers, for an honors seminar, perhaps a project off campus or work experience in the field of his interest — first attempts at real accomplishment in that field. There should be readily usable administrative machinery — it might be called an honors program — making it possible for an able student, perhaps under the guidance of a person as mentioned in the previous paragraphs, and under the general direction of a faculty committee, to have certain curricular freedoms and special opportunities to foster best his potentialities (*22, 23*).

It should be possible to adapt school and college programs to the needs of superior youngsters with regard to not only the nature of these programs but also their length. Occasionally a late start or an added year in school or college may be warranted. Far more often, an early start and rapid progress are desirable. Not only the occasional prodigy but most people of superior abilities show their superiority early and develop more rapidly than the average person (*17, 24*). Moreover, impressive evidence indicates that intellectual creativity reaches its peak relatively early in adult life (*11*). The practically universal American educational policy, nevertheless, is the lockstep: every child must enter school at 6 (none more than a month or so earlier), progress a grade a year, and, if he seeks advanced training, continue his schooling often till around 30, which was the median age of receiving the doctorate in this country just before World War II. Now, military service may delay even more the completion of education. Yet numerous studies are practically unanimous in showing that able children can enter earlier and progress more rapidly than the average child, without harm and often with gain in regard to realized abilities and social adjustment (*18, 24, 25*). Outcomes have been thus favorable in spite of most common use of the *worst* methods for "acceleration" — grade-skipping in school and a lengthened year in college. Better methods — admission to the first grade on the basis of readiness for school rather than chronological age, replacement of the first three grades by a "primary pool" out of which children would move early or late depending on when they finish primary work, rapid-progress sections doing 3 years' work in 2 in junior and senior high school, and credit by examination in college — should permit each youngster to move through educational programs at his own pace, without being conspicuous if his rate is not that of the average.

Not only are accelerates usually successful and happy in school, but they are more likely to complete collegiate and advanced training. At Ohio State University, 50 percent of the students entering when they were 16 years old graduated, but only 38 percent of the 18-year-old entrants paired with them according to tested general ability at entrance and type of program. With selection for acceleration and guidance therein, outcomes should be even better. Of a group of students selected in their freshman year as capable of finishing a 4-year program in less time and guided in so doing 63 percent graduated. Further, accelerates seem more often successful in their careers than individuals proceeding through their education at the usual pace. From 1880 to 1900, 29 percent of those graduating from Amherst at 19 became nationally known, as compared with 12 percent of those graduating at 22 (*18*). Of those in Terman's gifted group who graduated from high school under the age of 15 years and 6 months, 16 percent more graduated from college and 19 percent more took one or more years of graduate work than did those who finished high school when they were 16 years and 6 months or older, although there was little difference between the two groups in general ability when they were tested in childhood. (The average IQ's of the two groups at that time were 158 and 149, respectively). Moreover, twice as many of the first group (42 percent as compared with 19 percent) were very superior in respect to career (*17*, pp. 265–279).

In short, simply to increase the number of bright American youngsters who "accelerate" should substantially increase the number obtaining technologic or other advanced training and make it easier for precocious genius to emerge. If it were possible for bright youngsters not only to move through school more rapidly but also in other ways to have their programs adjusted to their special needs, still more might be expected to complete such training, still more successfully, and with still more notable careers following. Moreover, they would finish their training and get into their productive careers sooner. And educational costs would probably be reduced! Thus it seems a reasonable estimate that every year there remain in the secondary schools around 300,000 students whom a reasonable program of acceleration would have graduated. Such a reduction in enrollment would involve substantial savings, which might more than provide for the suggested special counselors for the gifted.

To meet the needs for trained manpower mentioned at the beginning of this paper, greater efforts to interest bright students in collegiate and advanced training programs (as they are now), better guidance of students in those programs, and more scholarship or other financial aid, have been suggested. The suggestion is here ventured that special facilitated programs adapted to the needs of the gifted would be the best means of interesting them, that special guidance in such programs (as suggested here) would best keep these students in school, and that such facilitated and early-completed programs (often including paid work experience) would substantially reduce the need for financial aid to students. Finally, the proposed special measures should produce more "geniuses." To produce persons of notable accomplishment, educational efforts should be directed straight toward that goal, in the light of all that can be found out about such persons and their upbringing. Simply to increase the number of students in physical education classes would probably *not* very much increase the number of athletic champions!

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14. N. Wiener, *Ex-prodigy* (Simon and Schuster, New York, 1953).
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16. C. M. Cox, *The Early Mental Traits of 300 Geniuses* (Stanford Univ. Press, Stanford, Calif., 1926).
17. L. M. Terman, *The Gifted Child Grows Up* (Stanford Univ. Press, Stanford, Calif., 1947).
18. S. L. Pressey, *Educational Acceleration: Appraisals and Basic Problems* (Ohio State Univ., Columbus, 1949), p. 11.
19. Subjects that might arouse early interest often cannot be started in high school. Thus, a youngster may have no opportunity to study psychology until his junior year of college. But trial of group discussion of social adjustment in junior-high-school and secondary-school home economics courses on "family life" have demonstrated the possibility of early beginning of a colloquial psychology. Children may be very shrewd in human relations. The opinion is ventured that precocity in psychology *should* be especially feasible. Such a youngster, entering adolescence with extensive relevant knowledge, might make distinctive contributions to knowledge of that period.
20. Wolfle (*1*, p. 251) has reported a study showing a substantial increase in the number of high-school students going to college as a result of a general school guidance program. A recent account (*21*) dramatizes possibilities of finding and furthering talent in even a small and isolated school.
21. F. V. Rummell and C. M. Johnson, "Bill Lane's students win the prizes," *Reader's Digest*, Jan. 1955, p. 29.
22. A program of this general type was for some years in effect at Ohio State University, but unfortunately it was dropped at the beginning of World War II, primarily because of lack of any such personnel specialist as has been urged in the preceding paragraphs. Many of the undergraduates in this program did research or service projects worthy of publication (*23*). The conventional honors program lacks the opportunities for work experience and for the research or service project (as distinct from a paper or library reading) that were found most distinctively valuable in the Ohio State University program.
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SUGGESTIONS FOR FURTHER READING

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PART V Behavior Is Developmental

Most of the stages of individual development fall within the experience of each of us. Whichever period we are now in is vivid, and those we have already experienced are still remembered, although they grow dim with time. We know something of other periods from close contacts with relatives and neighbors who are experiencing life at ages different from ours. The three earliest stages of human growth — germinal, embryonic, and fetal — we do not, of course, experience in the same way we do later periods. Birth is the only sharp demarcation between successive periods; the others move gradually from the neonatal stage to infancy to childhood to adolescence to young adulthood to middle age to old age without exact transition dates. Psychologists recognize these ten stages because of distinguishing behavior features found in each of them. Throughout all of life patterned behavior changes are going on which evolve from processes of growth, maturation, learning, and eventually aging. Growth refers to increase in size and other structural changes, maturation means refinement of functions occuring independently of experience, learning is that improvement directly traceable to experience, and aging is the normal process of tissue deterioration and its consequences in behavior change. These temporally patterned processes, when considered collectively, constitute ontogenesis, or the development of the individual.

There is still another powerful influence on our behavior which is also patterned through time. The evolutionary development of the species, first studied in terms of biological problems, has behavioral continuity as well. These processes are known, collectively, as phylogenesis, or the development of the species, and are studied from the behavioral point of view as comparative psychology. Behavioral data help us to understand the relationships among animals. The search for a comprehension of human behavior is not complete without a consideration of its evolutionary origins. As we examine behavior higher and higher on the animal scale we find emergent properties not present at a lower level, but we also find a patterned, progressive continuity from simple to complex forms. These are the reasons — the rationale — for our consideration of phylogeny.

In Part V will be found selections pertinent to both individual development and species comparisons. Learning from experience is the theme of the first selection, whereas maturation is stressed in the second. Gesell's emphasis is upon species patterning of the development of the individual. Munn clearly identifies the major phases of behavior phylogeny, and Warden takes up the specific question of species intelligence. Mrs. Hayes' selection shows the development of a subhuman species under extraordinary opportunity to learn, and the limitations to the effectiveness of training. In the last selection, Thorpe interprets experimental data to mean that the features of our behavior — learning, maturation, adaptiveness, and even purposefulness — can be found in lower animals.

29

Early Environment

WILLIAM R. THOMPSON AND RONALD MELZACK

A relatively new technique in the repertoire of the scientist interested in the development of behavior is that of modifying the normal stimulation pattern either by enrichment or severe deprivation at a critical stage. Experiments reported by this team of researchers represent five years of investigating sensory limitation in young puppies. Changes in personality, intelligence, emotional behavior, and even basic sensory factors are marked and enduring. Some of these results are nice examples of how common-sense predictions may be completely reversed when subjected to experimental check. In contrast to some other papers in the section, this selection stresses environmental variables in the determination of behavior.

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The child, as the poets say, "is father of the man," but we still know all too little about how the child is molded. It is a controversial as well as an interesting subject. Is intelligence, for instance, determined solely by heredity or can it be modified by the child's early environment? Although this question has been much studied, the evidence is ambiguous. And our understanding of the formation of the child's personality and emotional pattern is even more uncertain.

We do have some clear and definite information about the development of lower animals. While animals do not necessarily behave like human beings, experimental studies of them can shed light on basic reactions of organisms to their environment. From them a psychologist hopes to derive ideas which will help in studies of human beings.

The study we shall describe represents an attempt to find out how an animal is affected by severe restriction of its opportunities for development and learning during its first few months of life. Our subjects were Scottish terriers. We were interested in learning whether early upbringing in a barren environment would have permanent effects upon the dogs' intelligence, activity, emotional reactions and social behavior. The research was carried out over a period of five years in the psychological laboratory of McGill University with the help of a Rockefeller Foundation grant.

As soon as each litter of Scotties was weaned (at the age of four weeks), it was divided into two groups. One group was then raised normally as controls: the dogs were either farmed out to Montreal families or, in a few cases, reared as free pups in the laboratory. The members of the other group, who served as the experimental subjects, were all confined in cages — one dog to a cage. The cage was closed in with opaque sides and in some cases an opaque top, so that the dog could not see outside. Each day its food was placed in a small adjoining box with a sliding door. The door was opened from outside to let the dog into its "dining" room; then it was closed and the cage was cleaned. Thus the dog never saw its keepers.

The experimental animals lived in this blank, isolated environment until they were between seven and 10 months old. At the end of that time they were let out and given the same handling and daily exercise as the controls, which were brought back from their homes to the laboratory. The two groups were then observed and given various psychological tests.

It was immediately obvious even to a casual observer that restriction had had a profound and surprising effect on the experimental Scotties. After their release these dogs were exceptionally active and playful, showing a puppylike exuberance that belied their physical maturity. This behavior was almost opposite to what one might have expected, because it is commonly supposed that early separation from contacts with others has a depressing effect. Visitors to the laboratory, on being asked to pick out the restricted dogs from those raised normally, almost invariably chose the more sedate and subdued normal dogs.

We designed several tests to measure the Scotties' activity level systematically. In the first, each animal was put into a small room and observed for 30 minutes to see how much time it spent exploring the room, as opposed to merely sitting or lying down. This test was given four times, on four consecutive days, to seven normal and 11 restricted dogs. The normal dogs soon became bored with the monotony of the room and quietly relaxed, but those that had had a restricted upbringing went on exploring for a considerably longer time.

The amount of activity also varied inversely with age. Older dogs became bored much more readily than younger animals. This supports the idea that the behavior of the experimentals was a sign of immaturity.

In a second activity test, the experimental and the normal Scotties were invited to explore a maze. They were observed for four 10-minute sessions. At first both groups were equally curious. But the novelty of the situation wore off much more quickly for the normal animals, and their exploratory inspection of the maze rapidly declined, whereas the dogs that had been starved of experience in their early lives continued to run about in it more actively. Even several years after they had left their early cages, experimental Scotties still showed more activity in the tests than normally raised dogs of the same age — an indication that the effects of their early restriction were enduring.

These findings should not be interpreted to mean that maturity or a rich early life dulls curiosity. Rather they decrease over-curiosity. They produce an animal which is just as curious about any new situation, but which has the means to satisfy its curiosity quickly. In other words, the experienced animal exhibits more intelligence. There may be something delightful about a child who can spend an hour completely absorbed in a clothespin, but this is not intelligent, adult behavior.

We next examined the Scotties' emotional behavior. The severely limited early upbringing of the experimental dogs gave us a good opportunity to investigate the origin of so-called "irrational" or "spontaneous" fears, which have recently attracted much attention from psychologists.

It used to be thought that all fears of objects or stimuli were "conditioned" — an idea espoused by the behaviorist John B. Watson. The association of pain, a fall or a loud noise with an object may cause a child to fear it thereafter, even if the object is harmless. But many psychologists now are convinced that there is a type of fear which cannot be explained in terms of conditioning. Fear may be evoked simply by the unusual or the unexpected — a leaf suddenly swirling past one's face on a dark country road, a knock on a window at night, any mysterious happening or behavior. There is a classic case of a three-year-old girl who was severely frightened by her father when he dressed up as an elephant, even though she knew it was her father. D. O. Hebb of McGill University, investigating this type of fear systematically in chimpanzees, has found that they often show violent fear at the first sight of a strange person, a skull, a snake or a death mask of another chimpanzee. Charles Darwin long ago noticed the same phenomenon in dogs: in *The Descent of Man* he described how he had watched his dog avoid an open parasol being blown along the lawn by a breeze and had speculated on the dog's behavior. Darwin thought the dog must have reasoned unconsciously to itself "that movement without apparent cause indicated the presence of some strange living agent." It is doubtful that Darwin's dog, even after long association with a genius, could have reasoned in this way. Nonetheless, the significant fact Darwin recognized was that an animal with a highly developed brain may fear the mysterious.

Are such fears "innate" or developed? Helen Mahut of McGill University tested the reactions of various breeds of dogs, all reared normally, to certain harmless but emotion-evoking objects, and she discovered that each breed responded to these objects in a characteristic way. Thus the emotional behavior clearly must have some hereditary basis. Yet we can hardly assume that an animal is born with innate fears of specific objects or people. Obviously the animal's experiences determine to a large degree what is unusual and what is not. With our experimental Scotties, whose early experience had been extremely meager, we had an excellent opportunity to study the interaction of heredity and learning in determining emotional behavior.

About three weeks after the restricted dogs had been released from their cages, we exposed them to various strange phenomena, such as a human skull, a slowly swelling balloon, an opening umbrella and so on. Normally-reared young Scotties usually run away from such objects, without showing much excitement. But the restricted Scotties behaved very differently. They became highly agitated, jumped back and forth near the object, whirled around it, "stalked" it and generally displayed much excitement but little purposeful activity. Their behavior may be called "diffuse" or "undifferentiated" — they appeared not to know what to do about the object.

A year later the restricted and normal dogs were again tested with the same objects. The normal dogs now added a new response to their earlier avoidance: they attacked the object with a playful aggression — growling, barking, snapping and sometimes biting. The restricted dogs still showed considerable excitement of a diffuse kind, but they had also developed a purposeful pattern of avoidance. That is to say, they had reached a stage of response somewhat like that which the normal dogs had achieved a year earlier.

The experiment indicated that the hereditary pattern of adaptive emotional behavior, such as avoidance and aggression, emerges only after an animal has had considerable experience with a stimulating environment, acquired over a long period. Without such experience, the animal expends a great deal of undirected and ineffectual energy.

This experiment led to an even more interesting question: How will an animal deprived of experience respond to a stimulus which is painful rather than harmless? Is avoidance of pain a simple reflex reaction that comes naturally to any animal, as many psychologists have long assumed? Further experiments showed in the clearest possible fashion that it is not.

In one of these experiments the dogs were pursued by a toy car which gave them an electric shock when it hit them. Normal dogs quickly learned to avoid being hit. After six shocks, on the average, the experimenter no longer was able to touch them with the car. Moreover, they reacted to the threat calmly and deliberately: they sat watching the car, flicked aside a leg or the tail to avoid it, and jumped up to run away only at the last moment when the car came directly at them.

In contrast, the restricted dogs behaved wildly and aimlessly. They jumped about, galloped in circles and actually ran into the car when it was held still in their path. It took these dogs an average of 25 shocks each to learn to avoid the car, and even then they became excited whenever they saw it. Two of the experimental dogs were subjected to the test again two years after they had been released from restriction. They still reacted to the electric shock with the same wild agitation, and one of them learned to avoid the car only after 23 shocks.

In this and other tests of their responses to painful stimuli, some of which could have injured them seriously, most of the restricted dogs behaved as if they were unaware that the source of the pain was in the environment; they might have reacted in the same way to a bellyache. Whereas normal dogs usually dashed away from the pain-causing object, the restricted dogs spent considerably more time around it after they had been hurt than before. To the astonishment of the experimenters, these dogs often toyed with a painful stimulus and frequently walked into it. For example, they repeatedly struck their heads against some water pipes along the walls in one of the testing rooms: one dog banged his head against these pipes more than 30 times, by actual count, in a single hour. The dogs gave no sign of pain when they ran into the pipes.

These experiments support a great deal of other recent evidence that pain-avoidance is by no means the simple protective "instinct" it was long thought to be. It is not a mere matter of nerve stimulation and response. Both the perception of pain and the response to it are complex processes, in which the brain plays an important part. The appropriate response to pain is acquired, at least in part, by learning. And if an animal does not learn it in infancy, apparently it is unlikely ever to achieve the calm, precise response of a normal adult.

We made a number of direct tests of the restricted dogs' intelligence, or problem-solving ability. In one simple test the dogs were first trained to get food by running along a wall of a room from one corner to the next. Then the experimenter placed the food in some other corner of the room. This was done in full sight of the dog, and the experimenter called emphatic attention to the new position by banging the food pan on the floor. A normal dog usually ran straight to the new position. But the restricted dogs almost invariably ran pell-mell toward the old corner; at best they might veer off before they reached it and get to the correct goal by a roundabout route. In a variation of this test, a chicken-wire barrier was placed in front of the food to see whether the dog would be intelligent enough to go around the barrier. Again the restricted animals showed strikingly unintelligent behavior. Normal dogs usually learned to go around after one or two trials, but the puppylike restricteds repeatedly dashed up to the barrier, pawed at it and tried to push their muzzles through the mesh in a vain and frantic attempt to get at the food.

A more difficult delayed-response test measured the Scottie's ability to note and remember the location of food. Each dog was allowed to watch the experimenter put some food in one of a pair of boxes and to sniff the food. The dog was taken away and then released after a short time to test whether he would remember the correct box. Normal dogs, on the average, were able to choose the food box consistently after delays of up to four minutes. But the restricted dogs, as a rule, could not select the correct box reliably even when they were released without any delay at all.

The final test was a set of 18 different maze problems. The Scotties were scored on the number of errors they made and the time it took them to solve each maze and reach the food at the end of it. Two features of this series of tests seem to us especially noteworthy. In the first place, the 18 different mazes tested a wide range of abilities. And secondly, all the dogs were trained beforehand on simpler mazes so that they had practice and were proficient in solving the maze type of problem. This meant that the conditions were analogous to those obtaining in human intelligence tests, for the persons taking them have had previous training in answering questions of the sort asked in the test. Just as in testing human intelligence, one can hardly expect to appraise an animal's intelligence properly by presenting it with a single problem of a kind it has never encountered before, as is often done in laboratory maze tests.

As we expected, the restricted Scotties' performance on the 18 maze problems was substantially inferior to that of their normally reared littermates. They made about 50 per cent more errors on the series of problems. Even dogs which had been out of restriction for several years scored lower than their contemporaries, which seems to indicate that the retardation imposed by their early restriction was more or less permanent.

Having examined the effects of a barren early upbringing on the dogs' activity, emotionality and intelligence, we were curious to know how it would shape their social behavior. The social life of dogs is rather elementary compared with that of human beings. As any dog-owner can testify, the domestic dog is not a particularly social animal, as far as association with others of its own kind is concerned. Yet dogs certainly do interact socially when they have the opportunity. Their social behavior is determined partly by heredity (some breeds are notoriously more aggressive than others) and partly by upbringing.

We first studied the effect of a restricted upbringing on the trait of dominance (or submissiveness). The test situation was simple: a restricted dog and a normally raised dog were allowed to compete for a bone. Almost without exception the normal dogs dominated the restricted animals in this competition. Upbringing even overcame the powerful factor of seniority, for normal animals dominated the restricted ones that were considerably older.

The dogs were also compared on a test designed to measure "sociability." Each subject was released in a large room containing two other dogs, enclosed in separate chicken-wire pens in opposite corners of the room. The subject's interest in socializing was not difficult to measure. A sociable subject typically would approach one of the pens, stare at the animal inside, wag its tail and bark. Others ignored the occupants of the pens and sometimes even urinated on a pen as if there were no one inside. Our measure of sociability was the amount of time spent by the subject in taking social notice of the penned dogs during a 10-minute session.

In this test the normal Scotties proved to be much more sociable than those with a restricted upbringing. The latter paid little attention to the dogs in the pens, especially during the first session, and spent most of their time exploring the room itself. They were apparently a great deal more interested in the inanimate physical aspects of the room than in its live occupants. This lack of interest in companionship persisted years after the experimental dogs had been released from their early restriction.

The experiments we have described clearly indicate that a rich and stimulating environment in early life is an important condition for normal development. Restriction of experience during this crucial period can result in enduring retardation of an animal in various psychological traits. It must be emphasized that our studies of Scotties have little specific bearing on human beings, for the environmental situations are drastically different. But the experiments bring out clearly that any animal needs varied sensory stimulation in order to develop normally, just as it needs food and drink. This is a fact that has frequently been neglected by psychologists. It has long been assumed, either explicitly or implicitly, that all behavior is governed by a basic need to minimize tensions and disturbances in order to preserve the stability of the organism. This is evidently not so. Organisms like to be disturbed (as by an exciting novel, climbing a mountain and so on). And indeed they cannot live normally and fully if they are not. Especially during the early, plastic period of life, they must have a good deal of stimulation in their environment. If they do not, they may remain forever immature.

30

How Children Form Mathematical Concepts

JEAN PIAGET

Professor Piaget describes some remarkable observations concerning the manner in which number concept depends upon maturation level. The sequence or stages do not necessarily correspond with logical steps nor with the development of mathematical sophistication in the history of discovery. Piaget shows an interesting picture of the limited way in which the child perceives space and order and how the early stages are egocentric. Notice how, in the first paragraph, the author draws implications of his findings for the practical problem of teaching the child notions of number.

Professor Piaget is an internationally known research psychologist who is on the faculty of the University of Geneva, Switzerland. His work with children began at the Sorbonne thirty years ago and has led to numerous books and scientific reports. This article appeared in the *Scientific American* for November, 1953 (pp. 74–79), and is reprinted by permission of the publisher.

It is a great mistake to suppose that a child acquires the notion of number and other mathematical concepts just from teaching. On the contrary, to a remarkable degree he develops them himself, independently and spontaneously. When adults try to impose mathematical concepts on a child prematurely, his learning is merely verbal; true understanding of them comes only with his mental growth.

This can easily be shown by a simple experiment. A child of five or six may readily be taught by his parents to name the numbers from 1 to 10. If 10 stones are laid in a row, he can count them correctly. But if the stones are rearranged in a more complex pattern or piled up, he no longer can count them with consistent accuracy. Although the child knows the names of the numbers, he has not yet grasped the essential idea of number: namely, that the number of objects in a group remains the same, is "conserved," no matter how they are shuffled or arranged.

On the other hand, a child of six and a half or seven often shows that he has spontaneously formed the concept of number even though he may not yet have been taught to count. Given eight red chips and eight blue chips, he will discover by one-to-one matching that the number of red is the same as the number of blue, and he will realize that the two groups remain equal in number regardless of the shape they take.

The experiment with one-to-one correspondence is very useful for investigating children's development of the number concept. Let us lay down a row of eight red chips, equally spaced about an inch apart, and ask our small subjects to take from a box of blue chips as many chips as there are on the table. Their reactions will depend on age, and we can distinguish three stages of development. A child of five or younger, on the average, will lay out blue chips to make a row exactly as long as the red row, but he will put the blue chips close together instead of spacing them. He believes the number is the same if the length of the row is the same. At the age of six, on the average, children arrive at the second stage; these children will lay a blue chip opposite each red chip and obtain the correct number. But they have not necessarily acquired the concept of number itself. If we spread the red chips, spacing out the row more loosely, the six-year-olds will think that the longer row now has more chips, though we have not changed the number. At the age of six and a half to seven, on the average, children achieve the third stage: they know that, though we close up or space out one row of chips, the number is still the same as in the other.

In a similar experiment a child is given two receptacles of identical shape and size and is asked to put beads, one at a time, into both receptacles with both hands simultaneously — a blue bead into one box with his right hand and a red bead into the other with his left hand. When he has more or less filled the two receptacles, he is asked how they compare. He is sure that both have the same number of beads. Then he is requested to pour the blue beads into a receptacle of a different size and shape. Here again we see differences in understanding according to age. The smallest children think that the number has changed: if, for instance, the beads fill the new receptacle to a higher level, they think there are more beads in it than in the original one; if to a lower level, they think there are fewer. But children near the age of seven know that the transfer has not changed the number of beads.

In short, children must grasp the principle of conservation of quantity before they can develop the concept of number. Now conservation of quantity of course is not in itself a numerical notion; rather, it is a logical concept. Thus these experiments in child psychology throw some light on the epistemology of the number concept — a subject which has been examined by many mathematicians and logicians.

The mathematicians Henri Poincaré and L. E. J. Brouwer have held that the number concept is a product of primitive intuition, preceding logical notions. The experiments just described deny this thesis, in our opinion. Bertrand Russell, on the other hand, has supported the view that number is a purely logical concept: that the idea of cardinal number derives from the logical notion of category (a number would be a category made up of equivalent categories) while the notion of ordinal number derives from the logical relationships of order. But Russell's theory does not quite fit the psychological processes as we have observed them in small children. Children at the start make no distinction between cardinal and ordinal number, and besides, the concept of cardinal number itself presupposes an order relationship. For instance, a child can build a one-to-one correspondence only if he neither forgets any of the elements nor uses the same one twice. The only way of distinguishing one unit from another is to consider it either before or after the other in time or in space, that is, in the order of enumeration.

Study of the child's discovery of spatial relationships — what may be called the child's spontaneous geometry — is no less rewarding than the investigation of his number concepts. A child's order of development in geometry seems to reverse the order of historical discovery. Scientific geometry began with the Euclidean system (concerned with figures, angles and so on), developed in the 17th century the so-called projective geometry (dealing with problems of perspective) and finally came in the 19th century to topology (describing spatial relationships in a general qualitative way — for instance, the distinction between open and closed structures, interiority and exteriority, proximity and separation). A child begins with the last: his first geometrical discoveries are topological. At the age of three he readily distinguishes between open and closed figures: if you ask him to copy a square or a triangle, he draws a closed circle; he draws a cross with two separate lines. If you show him a drawing of a large circle with a small circle inside, he is quite capable of reproducing this relationship, and he can also draw a small circle outside or attached to the edge of the large one. All this he can do before he can draw a rectangle or express the Euclidean characteristics (number of sides, angles, etc.) of a figure. Not until a considerable time after he has mastered topological relationships does he begin to develop his notions of Euclidean and projective geometry. Then he builds those simultaneously.

Curiously enough, this psychological order is much closer to modern geometry's order of deductive or axiomatic construction than the historical order of discovery was. It offers another example of the kinship between psychological construction and the logical construction of science itself.

Let us test our young subjects on projective constructions. First we set up two "fence posts" (little sticks stuck in bases of modeling clay) some 15 inches apart and ask the child to place other posts in a straight line between them. The youngest children (under the age of four) proceed to plant one post next to another, forming a more or less wavy line. Their approach is topological: the elements are joined by the simple relationship of proximity rather than by projection of a line as such. At the next stage, beyond the age of four, the child may form a straight fence if the two end posts parallel the edge of the table, or if there is some other straight line to guide him. If the end posts are diagonally across the table, he may start building the line parallel to the table's edge and then change direction and form a curve to reach the second post. Occasionally a youngster may make a straight line, but he does so only by trial-and-error and not by system.

At the age of seven years, on the average, a child can build a straight fence consistently in any direction across the table, and he will check the straightness of the line by shutting one eye and sighting along it, as a gardener lines up bean poles. Here we have the essence of the projective concept; the line is still a topological line, but the child had grasped that the projective relationship depends on the angle of vision, or point of view.

One can proceed to study this with other experiments. For instance, you stand a doll on a table and place before it an object oriented in a certain direction: a pencil lying crosswise, diagonally or lengthwise with respect to the doll's line of vision, or a watch lying flat on the table or standing up. Then you ask the child to draw the doll's view of the object, or, better still, ask him to choose from two or three drawings the one that represents the doll's point of view. Not until the age of about seven or eight can a child deduce correctly the doll's angle of vision.

A similar experiment testing the same point yields the same conclusions. Objects of different shapes are placed in various positions between a light and a screen, and the child is asked to predict the shape of the shadow the object will cast on the screen.

Ability to coordinate different perspectives does not come until the age of 9 or 10. This is illustrated by an experiment I suggested some time ago to my collaborator Dr. Edith Meyer. The experimenter sits at a table opposite the child, and between the child and herself she places a cardboard range of mountains. The two see the range from opposite perspectives. The child is then asked to select from several drawings the ones that picture both his own and the opposite person's views of the mountain range. Naturally the youngest children can pick out only the picture that corresponds to their own view; they imagine that all the points of view are like their own. What is more interesting, if the child changes places with the experimenter and sees the mountains from the other side, he now thinks that his new view is the only correct one; he cannot reconstruct the point of view that was his own just a little while before. This is a clear example of the egocentricity so characteristic of children — the primitive reasoning which prevents them from understanding that there may be more than one point of view.

It takes a considerable evolution for children to come, at around the age of 9 or 10, to the ability to distinguish between and coordinate the different possible perspectives. At this stage they can grasp projective space in its concrete or practical form, but naturally not in its theoretical aspects.

At the same time the child forms the concept of projective space, he also constructs Euclidean space; the two kinds of construction are based upon one another. For example, in lining up a straight row of fence posts he may not only use the sighting method but may line up his hands parallel to each other to give him the direction. That is, he is applying the concept of conservation of direction, which is a Euclidean principle. Here is another illustration of the fact that children form mathematical notions on a qualitative or logical basis.

The conservation principle arises in various forms. There is first the conservation of length. If you place a block on another of the same length and then push one block so that its end projects beyond the other, a child under six will suppose that the two blocks are no longer of equal length. Not until near the age of seven, on the average, does the child understand that what is gained at one end of the block is lost at the other. He arrives at this concept of the conservation of length, be it noted, by a process of logic.

Experiments on a child's discovery of the conservation of distance are especially illuminating. Between two small toy trees standing apart from each other on a table you place a wall formed of a block or a thick piece of cardboard, and you ask the child (in his own language, of course) whether the trees are still the same distance apart. The smallest children think the distance has changed; they are simply unable to add up two parts of a distance to a total distance. Children of five or six believe the distance has been reduced, claiming that the width of the wall does not count as distance; in other words, a filled-up space does not have the same value as an empty space. Only near the age of seven do children come to the realization that intervening objects do not change the distance.

However you test them, you find the same thing true: children do not appreciate the principle of conservation of length or surface until, somewhere around the age of seven, they discover the reversibility that shows the original quantity has remained the same (e.g., the realignment of equal-length blocks, the removal of the wall, and so on). Thus the discovery of logical relationships is a prerequisite to the construction of geometrical concepts, as it is in the formation of the concept of number.

This applies to measurement itself, which is only a derived concept. It is interesting to study how children spontaneously learn to measure. One of my collaborators, Dr. Inhelder, and I have made the following experiment: We show the child a tower of blocks on a table and ask him to build a second tower of the same height on another table (lower or higher than the first) with blocks of a different size. Naturally we provide the child with all the necessary measuring tools. Children's attempts to deal with this problem go through a fascinating evolution. The youngest children build up the second tower to the same visual level as the first, without worrying about the difference in height of the tables. They compare the towers by stepping back and sighting them. At a slightly more advanced stage a child lays a long rod across the tops of the two towers to make sure that they are level. Somewhat later he notices that the base of his tower is not at the same level as the model's. He then wants to place his tower next to the model on the same table to compare them. Reminded that the rules of the game forbid him to move his tower, he begins to look around for a measuring standard. Interestingly enough, the first that comes to his mind is his own body. He puts one hand on the top of his tower and the other at its base, and then, trying to keep his hands the same distance apart, he moves over to the other tower to compare it. Children of about the age of six often carry out this work in a most assured manner, as if their hands could not change position on the way! Soon they discover that the method is not reliable, and then they resort to reference points on the body. The child will line up his shoulder with the top of his tower, mark the spot opposite the base on his thigh with his hand and walk over to the model to see whether the distance is the same.

Eventually the idea of an independent measuring tool occurs to the child. His first attempt in this direction is likely to be the building of a third tower next to and the same height as the one he has already erected. Having built it, he moves it over to the first table and matches it against the model; this is allowed by the rules. The child's arrival at this stage presupposes a process of logical reasoning. If we call the model tower A, the second tower C and the movable tower B, the child has reasoned that $B=C$ and $B=A$, therefore $A=C$.

Later the child replaces the third tower with a rod, but at first the rod must be just the same length as the height of the tower to be measured. He then conceives the idea of using a longer rod and marking the tower height on it with his finger. Finally, and this is the beginning of true measurement, he realizes that he can use a shorter rod and measure the height of the tower by applying the rod a certain number of times up the side.

The last discovery involves two new operations of logic. The first is the process of division which permits the child to conceive that the whole is composed of a number of parts added together. The second is the displacement, or substitution, which enables him to apply one part upon others and thus to build a system of units. One may therefore say that measurement is a synthesis of division into parts and of substitution, just as number is a synthesis of the inclusion of categories and of serial order. But measurement develops later than the number concept, because it is more difficult to divide a continuous whole into interchangeable units than to enumerate elements which are already separate.

To study measurement in two dimensions, we give the child a large sheet of paper with a pencil dot on it and ask him to put a dot in the same position on another sheet of the same size. He may use rods, strips of paper, strings, rulers or any other measuring tools he needs. The youngest subjects are satisfied to make a visual approximation, using no tools. Later a child applies a measuring tool, but he measures only the distance of the point from the side or bottom edge of the paper and is surprised that this single measurement does not give him the correct position. Then he measures the distance of the point from a corner of the paper, trying to keep the same slant (angle) when he applies the ruler to his own sheet. Finally, at about the age of eight or nine, he discovers that he must break up the measurement into two operations: the horizontal distance from a side edge and the perpendicular distance from the bottom or top edge. Similar experiments with a bead in a box show that a child discovers how to make three-dimensional measurements at about the same age.

Measurement in two or three dimensions brings us to the central idea of Euclidean space, namely the axes of coordinates — a system founded on the horizontality or verticality of physical objects. It may seem that even a baby should grasp these concepts, for after all it can distinguish between the upright and lying-down positions. But actually the representation of vertical and horizontal lines brings up quite another problem from this subjective awareness of postural space. Dr. Inhelder and I have studied it with the following experiments: Using a jar half-filled with colored water, we ask our young subjects to predict what level the water will take when the jar is tipped one way or another. Not until the age of nine, on the average, does a child grasp the idea of horizontality and predict correctly. Similar experiments with a plumb line or a toy sailboat with a tall mast demonstrate that comprehension of verticality comes at about the same time. The child's tardiness in acquiring these concepts is not really surprising, for they require not only a grasp of the internal relationships of an object but also reference to external elements (e.g., a table or the floor or walls of the room).

When a child has discovered how to construct these coordinate axes by reference to natural objects, which he does at about the same time that he conceives the coordination of perspectives, he has completed his conception of how to represent space. By that time he has developed his fundamental mathematical concepts, which spring spontaneously from his own logical operations.

The experiments I have described, simple as they are, have been surprisingly fruitful and have brought to light many unexpected facts. These facts are illuminating from the psychological and pedagogical points of view; more than that, they teach us a number of lessons about human knowledge in general.

31

Human Infancy and the Ontogenesis of Behavior

ARNOLD GESELL

Although Gesell and his associates have patiently studied the development of human behavior in greater detail than has anyone else, he makes an appeal for still more investigation of psychological development, for he knows so well that the scientist's job is never done. In this article Dr. Gesell traces the manner in which coordinate behavior slowly evolves from a varied, but diffuse, early stage. Three areas of behavior are discussed — control of body parts, language and thought, and the interpersonal self. The author stresses the patterning of development laid down by species inheritance, although some other psychologists would give at least equal emphasis to stimulating factors in the environment.

Dr. Gesell holds both the PhD and the MD degrees. For many years he was director of the Institute for Child Development at Yale which bears his name, and he is the author of several well-known books on human development. He is now research consultant for the institute. The article below is based upon a national Sigma Xi lecture and was published in the October, 1949, issue of the *American Scientist* (pp. 529–553). It is reprinted by permission of the publisher and Dr. Gesell.

NOTE: Six figures have been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the author's permission.

Human infancy is a period of genesis and growth. But the genesis of this genesis must be sought in the vastly longer period of organic evolution. The human infant in a true sense is the focal end product of countless ages of racial prehistory. Infancy was evolved to subserve the needs of individual growth and to supply the conditions for continuing evolution.

INFANCY AND THE LIFE CYCLE

Every infant, accordingly, comes into the world with potentialities of growth which normally perpetuate the essential traits of the species. He is also endowed with a margin of modifiability which makes for innovation and mutation. No one needs to teach him how to grow. The capacity to grow is an intrinsic part of the instinct to survive. The tendency of all growth, both in normal and in handicapped children, is toward an optimal realization, and Nature is prolonging the period of infancy to permit a wider and higher range of realization.

George Bernard Shaw, however, is not altogether satisfied with these arrangements, and indictates that by the year 31,920 A.D. Nature may have improved her techniques. In his *Back to Methuselah: A Metabiological Pentateuch*, he pictures a dramatic scene in which a huge egg upon an altar begins to rock. Presently there emerges "The Newly Born, a pretty girl who would have been guessed as seventeen in our day." She "sits up in the broken shell, exquisitely fresh and rosy, but with filaments of spare albumen clinging to her here and there." She had been growing for two years in the egg and in that time passed through a development which nowadays (1920–1949) cost human beings some twenty years of "awkward stumbling immaturity" after they have been born.

Despite these whimsical strictures, the human life cycle as of today remains biologically a most complicated and even an awe-inspiring spectacle. Into the early sectors of this cycle there are compressed millions upon millions of years of prehuman evolution. The germinal cells which initiate a cycle of growth are, in a sense, very new, but each has a phyletic history which recedes into remote geologic epochs. By the same token, the embryo, fetus, and newborn infant are biologically very ancient. The toddler walks and leans with a posture which suggests primitive mankind. Yet he is at the same time so untutored in our modern culture that we rightfully regard him as something unique and recent under the sun.

Phylogenesis and ontogenesis are so profoundly interrelated that the cycle of development is charged with paradoxes and relativities. The younger the organism, the faster it grows old. Newtonian time, which we use to measure chronologic age, flows at a uniform rate in either direction. But development flows with a negative acceleration in unidirectional time, and, of course, it is irreversible. If an infant is born prematurely, he has three ages: statutory chronologic age, registered by the bureau of vital statistics: corrected chronologic age, which discounts for his prematurity and is reckoned from conception; developmental age, which expresses his biologic completeness on the basis of a developmental diagnosis. For accuracy, he must be called a fetal-infant during the period of his prematurity, that is, from birth until he reaches a postconception

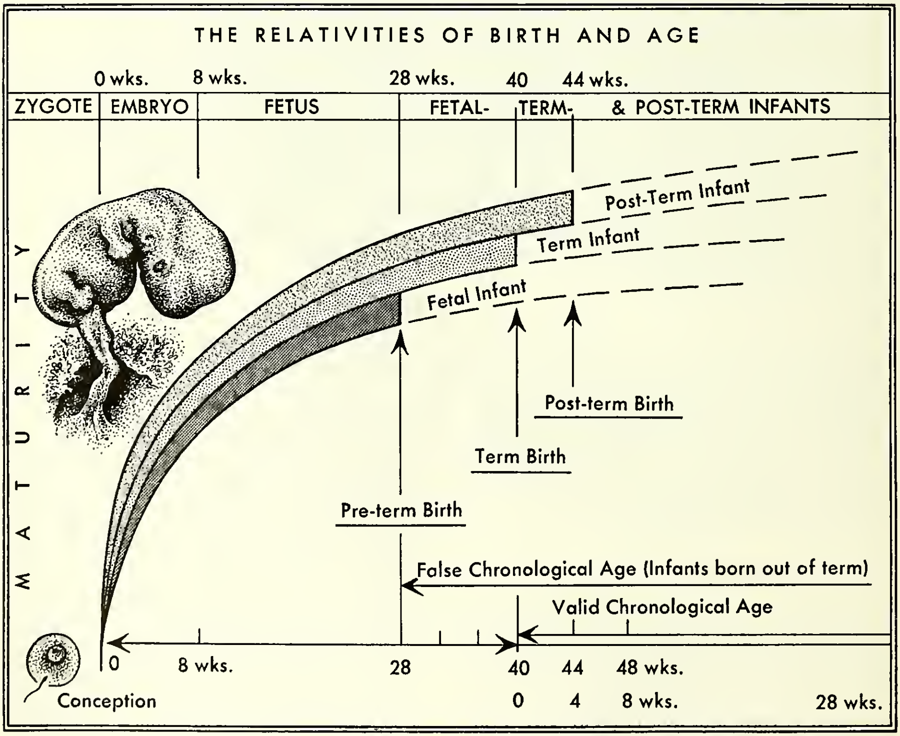

Fig. 1. A diagram of the relativities of birth and age. The *fetal-age* scale extends from the zero of conception to 40 weeks. (From Gesell, *Embryology of Behavior.*)

age of forty weeks (Fig. 1). Our clinical studies have shown that uncomplicated prematurity does not markedly alter the course of postnatal development. Irrespective of the time of birth, the viable infant tends to cleave to a basic ontogenetic sequence.

UTERINE DEVELOPMENT

Ontogenesis *in utero* and *ex utero* reveals itself in three major manifestations: somatic, physiologic, and behavioral. At a postconception age of eighteen days, the human embryo, as shown by the Heuser specimen, is a patch of protoplasm, measuring 1.53 mm. in length and 0.75 mm. in its greatest width. The ground plan of a potential organism is already foreshadowed in the construction of this tiny disk of tissue. The longitudinal axis has been laid down: the embryo has a left and a right side, a dorsal and ventral aspect. The primitive node, a conspicuous white spot behind the center of the disk, marks the junction of the head and neck. Indeed, almost three-fourths of the disk is already set aside for the formation of the head (*1*).

Human development places a premium on the head — and on the heart. Morphogenesis proceeds at a prodigious pace. Presently the embryonic heart takes shape. By the fourth week it begins to beat, initiating the most durable of all behaviors. The eyes are almost equally precocious. By the end of the fourth week the optic vesicles are fully formed. In the fifth week limb buds, precursors of arms and hands, emerge. In the sixth week the retina of the eye, and in the seventh week the semicircular canals of the ear and the oculomotor muscles, begin to differentiate. Near the eighth week the region about mouth and neck become reflexogenous. Hooker, in his notable studies, has shown that at this stage stroking this area with a hair stylus elicits a lateral flexion of trunk and neck with slight rotation of the pelvic region. At the same time shoulder muscles contract causing the arms to move stiffly backward. In a half-second the fetus returns to the original attitude (2).

Thus it has been demonstrated that approximately eight lunar months prior to birth the embryo is capable of an overt configured pattern of behavior. The patterning of behavior continues in a regular ontogenetic sequence, generally from head to foot and from proximal to distal segments. By the fetal-age of twelve weeks a wide variety of muscle reactions make their appearance, most of them involving the fetus as a whole. There are spontaneous rhythmic contractions of the trunk alternating from side to side. By this time the semicircular canals have attained adult size, and it is quite possible that the fetus already responds with some aquatic skill to stimuli from the vestibular apparatus of the ears. Fingers have formed; stimulation of the palm elicits extension of the wrist, and, at a somewhat later stage, the fingers flex and grip. By twelve weeks the arms and hands have rotated from the early paddle position, so that the palms now face each other. In response to a facial stimulus, both hands may move toward the median plane. This bilateral response foreshadows in an interesting manner a comparable prehensory reaction of the full-term infant at the postnatal age of twenty weeks, when the total reaction comes under visual voluntary control. We may call this a symmetrotonic reflex, bearing in mind that asymmetric patterns of behavior will appear in later development.

It is not too early to consider vision. Even though the eyelids at the fetal-age of twelve weeks are still fused, the prerequisites for eye-hand coordination are already in the making. The oculomotor muscles are undergoing innervation, and the eyeballs have been observed to move beneath their sealed lids. These eye movements increase in strength and in pattern as the fetus matures. It is impressive to realize that the eyes are active in a motor sense throughout a period of seven lunar months prior to full-term birth.

The fourth month of gestation is in many respects the most variegated in the prenatal ontogenesis of behavior, because the fetus exhibits an extremely diverse repertoire of elementary movement patterns. In fact the entire skin is becoming reflexogenous. Restricted specific reactions supplement the general postural responses, but the action system maintains a basic unity. The specific patterns arise through individuation out of a total unitary pattern. The patterns may at times function in apparent isolation, but there is no adequate evidence that the ontogenesis of behavior proceeds by a linking together of multiple independent specific reflexes.

By the end of the fifth gestation month the fetus is approximately a foot in length and a pound in weight, and is well advanced both in somatic and functional organization. The countenance has taken on a somewhat personable appearance and is already stamped with individuality. Although the nervous system is by no means finished, the infant is in possession of a full quota of neurones, perhaps twelve billion in number.

The mechanisms of vision are now still further advanced. Although the fetus has no light by which to see, the anatomical arrangements for seeing have been deeply laid. The optic nerve is equipped with its million fibers, ninety per cent of them reaching the cortex by way of the lateral geniculate bodies, which serve as a mediating mechanism for the macula, the area of most acute vision. The macula begins to differentiate as early as the third gestation month. In another fortnight the layers of the retina will have been differentiated, the fovea centralis in each retina established by a thinning of the ganglion cells to form a shallow surface depression. At the time of its formation the fovea is as far distant from the optic nerve head as it is in the adult eye — an arresting fact when one considers the tremendous anatomical changes which are yet to follow during the latter half of the gestation period and throughout the postnatal period of growth, for the eye itself will more than double in weight prior to birth. Moreover, the eye and the brain will increase three and one-half times in weight from birth to maturity, and the body as a whole will increase twenty-one times. Nevertheless, the distance between the fovea and the nerve head established at the fetal-age of twenty-four weeks remains unchanged (3).

This fact certifies to the profound importance of vision in the organization of human behavior. The macula in a sense becomes a fixed pivot in the process of morphogenesis. This is also an impressive instance of developmental fore-reference, because macular vision with its rich cortical and subcortical elaborations requires many years of continuing development throughout infancy and childhood. Theoretically, this anachronistic mixture of adult and embryonic characters indicates the limitations of a simple chronological concept of recapitulation (4).

Nature has a double problem: to crowd as much development as possible into the uterine period, and, at the same time, to make ample anticipatory provisions for a distant future. Moreover, there is the additional and fateful contingency of premature birth. Always there is the difficulty of reconciling the physiology of the maternal organism with that of the "parasitic" fetus. Often the difficulty is so great that gestation miscarries, and the fetus is stillborn or blemished. These complications are mentioned in passing, because they affect the ontogenesis of human behavior. Prenatal development is dependent upon degrees of compatibility between the life cycles of mother and child.

THE FETAL-INFANT

At no point in the cycle of human life do individuals exhibit such a wide array of differences as at the moment when they are born. This is due to the relativities of natal age, to congenital differences in physiological adequacy, and to differences in behavioral capacity. Infancy begins at birth. A full-term infant is one whose gestation period was approximately forty weeks. A pre-term or premature infant is one whose gestation period was less than thirty-seven weeks (birth weight 2500 grams or less). A pre-term infant is called a fetal-infant from birth to the fortieth postconception week, as reckoned by birthweight age.

As an insurance factor against the hazards of premature birth, the machinery for breathing, involving cooperation of nerve elements, undergoes a hastened development in the fifth, sixth, and seventh gestation months. A single shallow exhalation followed by inhalation has been observed even earlier. In a surgical fetus twenty-two weeks old, the spasm movements occurred in short runs of two or three exhalations and inhalations. By twenty-five weeks these rhythms are no longer spasmodic, but sufficiently continuous to support life for several hours (5). By twenty-eight weeks the respiratory mechanism is usually sufficiently advanced, under conditions of modern pediatrics, to insure survival followed by relatively normal development.

At this early stage (twenty-eight to thirty-two weeks) the fetal-infant is small enough to be held in the palm of the adult hand. The muscular tone is minimal, flaccid, and uneven. Occasionally there is movement, but the distinction between activity and rest is not clear-cut. The fetal-infant neither really sleeps nor wakes, but only drowses with brief periods of bodily activity. The torpor is fluctuant and shallow, but is the most conspicuous and consistent behavior at this stage. In the supine position the infant tends to lie with head turned to one side with the arm on that side extended, the opposite arm being flexed. This represents the classic tonic-neck-reflex (t-n-r) pattern which is of far-reaching significance in the patterning of behavior. The symmetro-tonic-reflex (s-t-r) is characteristic of an earlier fetal-stage. At times the fetal-infant activates the extended arm and holds it in a transient catatonic pose. Although general bodily activity is sporadic and meager, he is seldom completely quiescent for any length of time. The facial musculature is busy: the tongue protrudes; the lips purse, munch, and mince; the eyelids flutter in unison or in succession; the eyebrows lift together or separately; the forehead corrugates (sometimes only half of the brow is involved, for bilateral integration is not yet firmly achieved); the oculomotor muscles roll the eyeballs or weave them back and forth and up and down; the eyeballs usually move conjointly, but positive visual responses are scanty or quite absent.

In another month (thirty-two to thirty-six weeks) the fetal-infant, although still a drowsy individual, shows a capacity for brief periods of wakeful alertness. Again and again during the day and during the night, the torpor is disrupted by small acts of awareness. The infant does not give true regard to an object slowly moved across the field of potential vision, in fact he does not even fixate upon it, but the eyes do move irregularly in brief after-pursuit.

The late-stage fetal-infant (thirty-six to forty-weeks) presents a more finished appearance. Increased deposits of fatty tissue have rounded the body contours. He is physiologically more robust, and the behavior patterns are more distinctly configured. Having had a month or more of experience in an atmospheric world, he functions more smoothly, if not more maturely. He has learned the knack of sleeping, and he falls off to sleep more decisively, sleeps more deeply, clings to sleep more tenaciously. During the brief waking interludes he takes some visual notice. The ability to wake up, like all complex behaviors, is based upon morphogenetic changes in the central nervous system. The waking propensity requires special neurological arrangements which, at the present stage, are probably organized chiefly in the thalamic region of the brain — the equivalent, according to Kleitmann, of a primitive waking center. When the late-stage fetal-infant reaches a postconception age of forty weeks, he is chronologically equivalent to a newborn infant of full term. Premature birth has provided lengthened experience in a world of light and air. The behavior characteristics observed at this stage afford some indication of the ontogenesis which takes place unobservably in the latter months of full-term uterine development.

Having had some weeks in which to refine his adaptations to an extrauterine environment, the fetal-infant may function more smoothly than the full-term neonate of equivalent postconception age. For a brief period the more experienced infant appears better organized and physiologically more expert, but these differences are transient and do not confer any permanent fundamental acceleration.

The fact that prematurity, uncomplicated by damage or disease, has no marked effect upon the sequences of behavior development, indicates that the entire course of ontogenesis is well ballasted by intrinsic maturational determiners. Maturation may be defined as the net sum of the gene effects operating in a self-limited life cycle. Genes received by an individual may be regarded as agents which control biochemical reactions in a sufficiently specific manner to determine the basic sequences of ontogenesis. These sequences manifest themselves in characteristic body structures and equally characteristic forms of behavior.

We have dwelt at some length on the prenatal phases of ontogenesis, because they illustrate most strikingly the power of the maturational mechanisms. There is no evidence that these same mechanisms cease to operate during the postnatal periods of infancy and childhood. To be sure, the newborn infant is plunged into a novel environment, highly charged with complex cultural forces which impinge upon him relentlessly during all his waking hours. Nevertheless, both by night and by day, the maturational mechanisms, based upon the gene complex, proceed with comparable relentlessness.

The impacts of culture are incessant but by no means all-powerful. The infant is durable as well as docile. The degrees and the directions of his acculturation are in no small measure determined by inherent behavior traits and trends.*

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* A brief parenthetical statement should be inserted to indicate the methods that were used to collect the underlying data which reveal these trends. The main observations were made at the Yale Clinic of Child Development, under a cooperative and systematic program of research conducted in close affiliation with a diagnostic service, which brought us into contact with a wide variety of normal, atypical, and abnormal infants and children. The basic investigation was concerned with the progressions of normal behavior development, observed under both standardized and naturalistic conditions. Behavior traits were charted and codified for thirty-four age levels from the period of fetal-infancy through the first ten years of life. The data were secured by means of interviews, home visits, guidance nursery observations, stenographic records of developmental examinations, and extensive motion photography. A naturalistic cinema survey was made in domestic surroundings with the aid of concealed and silenced cameras. Most of the normative survey was accomplished by means of a specially constructed observation dome encased in a one-way-vision screen. Sixteen-millimeter recordings were made at lunar month intervals during the first year of life, and at longer intervals thereafter.

The cinema records were subjected to frame-by-frame analysis by means of a specially designed viewer to discover and to define the significant morphogenetic trends in

These postnatal developmental trends may be conveniently outlined under the following headings: (1) Eyes-Hands-Feet; (2) Language and Thought; and (3) The Interpersonal Self.

EYES-HANDS-FEET

In the evolution of prehuman behavior, it appears that the olfactory area and the sense of smell began to recede when the forelimbs were freed for purposes of prehension and feeding. Eocene Tarsius must have lived on a hand-to-mouth basis, with increasingly alert eyes. This involved an enormous development of the portion of the cerebral cortex responsible for vision. All that has happened since in the anthropoid humanoid stocks, which emerged after the Tarsiers, has tended to enhance and to enrich the visual functions. The brain nucleus for accommodation was remodelled in the primates, and was divided so that each eye could be focused independently upon any object. The sense of smell, once in the lead, has declined, and the eyes have attained a priority in the constellation of the sense organs. The eye, however, has not become overspecialized, but continues to show a remarkable adaptability in meeting environmental demands without exaggerated development of any one of its several components at the expense of others. Overspecialization would have led to isolation from other areas of sense and movement. This generalized biological adaptability suggests that even under cultural stress the human eye will prove equal to new demands and maintain a supremacy without weakening the unity of the action system. It is evident that its evolutionary potentialities have by no means been exhausted (6).

The human hand, likewise, remains in a primitive and very generalized condition, and may well continue capable of many new refinements in the evolution of the action system. Something also should be said about the foot of man. Although it is not directly concerned in the mechanisms of vision, the foot is one of the most specialized and distinctive features of human anatomy. In a very real sense, it is the foundation of distinctive visual skills, because the feet have become the "arch platforms" which permit man to maintain an erect posture and to bestride the earth as a partial master of destiny, eyes forward. This posture and distinctive mode of locomotion have also favored reorientations and new conquests in the sphere of vision. The forces of evolution had to provide continuously for a harmonious interadjustment between eyes, hands, and feet. In this sense, the feet do figure in the economy of vision and cannot be disregarded in any account of the ontogenesis of child behavior.

In the early patterning of behavior the eyes assume a lead, and in a sense the infant takes hold of the world with his eyes long before he does so with his hands. During the first eight weeks of life the hands are predominantly closed, but the eyes open to fixate, to stare, and to seek. Conjugate and coordinate compensatory eye movements are present soon after birth. Incipient fixation of an approaching object in the field of vision is observable in the first day of life, longer fixation in the first week, and well sustained fixation of near and far objects at the end of the first month. In its earliest stage, fixation is typically monocular. The active eye immobilizes except for minute lateral and vertical movements which cause the fovea to traverse a stimulus area. The non-fixating eye rests or wanders willy-nilly. In the next stage the monocular fixation alternates rapidly from one eye to the other, the shifts being accompanied by a rhythmic left-to-right-to-left rotation of the head (*10*).

This interesting stage of monocular alternation of dominance leads directly into binocular convergence, which makes its appearance in the second month. The teaming of the two eyes is an extremely complicated phenomenon. It involves complex aspects of fusion, stereopsis, and cortical interpretation, which undergo progressive organization throughout the years of infancy and childhood. During the third month transfixed regard

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the patterning of behavior. Cinemanalysis is a method of observation which permits us to examine objectively, repeatedly, and quantitatively, the successive phases of recorded motion. The observer controls the successive images by a hand crank. He employs the analytic viewer in much the same way that he would use a microscope for histologic studies. Indeed, cinemanalysis renders the visible behavior traits as tangible as tissue, and makes it possible to investigate the morphology of the behavior patterns.

The systematic surveys were supplemented by experimental studies of special aspects of behavior, such as eye movements, visual fixation, prehension, etc. The early development of visual behavior has been explored by visual skills tests and retinoscopic examinations (7). Relationships between learning and growth were investigated by the method of co-twin control (8). A wide variety of clinical cases were periodically examined on the diagnostic service to determine the influence of developmental defects and deviations on the course of behavior patterning. Norms of development were formulated for clinical applications. Typical behavior patterns were pictorially delineated and codified in *An Atlas of Infant Behavior* (9).

gives way to roving inspection, and the eyes begin to look selectively at objects which move in the field of near vision.

The tonic-neck-reflex attitude now proves to be a significant factor in the developmental organization of visual behavior. Repeatedly and often prolongedly, the infant gazes in the direction of his extended arm, as though he were regarding his own hand, whether moving or still. This attitude promotes and channelizes his visual fixation; it leads to fleeting eye-hand coordinations, later to prehensory approach, and eventually to various forms of unidexterity — eyedness, handedness, and also footedness.

In another month, at sixteen weeks, the hands decisively enter the behavior picture, supplementing and even activating the posturing of the eyes. When the infant is supine, the head now favors a mid-position rather than aversion, and concurrently the hands come toward the midplane, to engage, to clutch, and to finger. "Fingers finger fingers," thus bringing active and passive touch into close association. The infant cannot reach on sight, but in response to a tactile cue an object is grasped after it is placed in the palm.

Nevertheless, eyes and hands are coming into coordination. This is beautifully shown when the infant is propped in a supportive chair, confronting a gray table top, on which a red one-inch cube is placed. The infant is pleased with this sedentary position, and feels an urge to erect eyes, head, and shoulders. He is avid for visual experience, and holds his head steady, looks down intently at the table top, at his own hand, at the cube, again at his own hand, and perhaps again at the table top. One or both hands begin to scratch the surface of the table. Presently he shifts his regard to the surroundings or the nearby experimenter. (We have performed an experiment in which a stimulus object is administered under carefully standardized conditions, and which permits comparisons from object to object, from age to age, and from child to child.) Repeating the cube test on numerous subjects, we find that there is a consistent difference in the visual-motor responses at advancing age levels. The behavior patterns fall into growth gradients, which reflect lawful sequences of ontogenesis.

In another lunar month, when the infant is twenty weeks old, we place upon the table top a white pellet 7 mm. in diameter. The infant gives it definite regard, the hand usually remaining passive, for this is an exacting visual test. He unquestionably picks up the pellet with his eyes, even though he will not pick it up readily with his fingers until twice his present age. At forty-four weeks he plucks the pellet promptly with precise pincer prehension and neat thumb opposition.

These are genuine ontogenetic phenomena. Prehension is not a mere skill, acquired through practice and learning, for at each progressive age the infant functions with a new mode of response in the following genetic order: (1) fitful, sketchy regard of the 7 mm. pellet (twelve weeks); (2) definite regard of pellet without manual approach (twenty weeks); (3) prehends one-inch cube on sight (twenty-four weeks); (4) rakes in vicinity of pellet with conjoint flexion of fingers (twenty-eight weeks); (5) prehends pellet on sight, by crude lateral forceps approach (thirty-six weeks); (6) prehends pellet pincerwise by adept oblique approach (forty-four weeks). Under the stress of intrinsic growth, the human infant is constantly abandoning one form of behavior for another form which is maturationally more appropriate. Even after he has "learned" to take up (and eat) a sugar pellet, with dispatch, by a gross palmar scoop, he adopts a more delicate and difficult digital method of prehension, using it persistently despite initial awkwardness and failure.

The environment lacks the architectonics to generate such basic progressions and reconfigurations in the patterning of infant behavior. There appears to be a ground plan of development governed by an inherent dynamic morphology imposed by the phyletic history and by the developmental anatomy of the human action system. The combined developmental and morphological trends are so profoundly related to gravity, light, and space that they can conceivably be reduced to mathematical formulation, as already adumbrated in D'Arcy Thompson's classic work *On Growth and Form.* Ontogenesis is an organic time-space cycle of forms, whether considered physically or functionally. Thompson has given the most succinct definition of a form; it is "a diagram of forces."

An ontogenetic sequence is evident in the formation and transformation of cube behavior observable during the first five years of life. At twenty-four weeks of age the infant at the test table leans forward and seizes a cube on sight. At twenty-eight weeks, having seized the cube, he transfers and retransfers it from one hand to the other — a remarkably universal behavior pattern, entirely untaught, and without even the reinforcement of a nursery game. At forty weeks a cube is held in each hand and the two brought together exploitively in the midplane. At one year, with several cubes before him, the infant picks them up one by one and releases them one by one, exercising a new power of voluntary inhibition. This seriational behavior is an ontogenetic prerequisite for a higher action pattern which is called counting. The infant tends to release the cubes in random array; but at eighteen months, spontaneously and responsively he builds a tower of blocks — a vertical seriation, and at two years builds a wall — a horizontal seriation. At three years he surmounts two buttress cubes with a third, combining horizontal and vertical components in the construction of a bridge. At four years the keystone cube is tilted by an oblique maneuver to make a gate. At five he rearranges six cubes into a three-step stairway, combining vertical, horizontal, and oblique directionalities. "Nature geometrizes," said Plato. Her geometry is implicit in the development anatomy of the nervous system. It is tempting to suggest that the developmental trends which the child shows in the various stages of his block play and block building in some way correspond with the stages through which the race passed in its primitive contests with gravity and space.

Early man began to contrive and to use tools as soon as he adopted the erect posture, which served to free his forelimbs for the higher uses of manipulation. Eyes came into their own. Vision became more completely the master guiding sense, directing his fumbling hands and feet into increasingly elaborate pathways. With respect to the interaction between eyes, hands, and feet, it is idle to differentiate between cause and effect. Recent fossil finds in South Africa suggest that a prehuman Plesianthropus walked erect with eyes front, some 7,000,000 years ago.

It takes the average human infant about sixty weeks to attain the ability to walk alone, even with a toddling gait. The developmental mechanics of this locomotor ability are extremely intricate. The diagonal reflexes and the tonic-neck-reflex postures of the fetus are part of the ontogenetic sequence. We have identified twenty distinguishable stages of postnatal prone behavior, beginning with a passive kneeling stance and culminating in plantigrade creeping, a quadrupedal form of locomotion on palms and soles (Fig. 2). The final transition from quadrupedal to bipedal walking may be rather

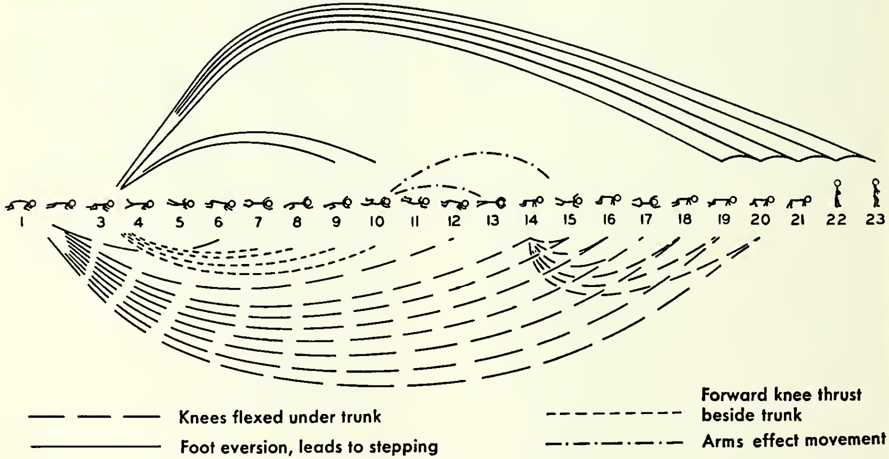

Fig. 2. Diagram to illustrate the developmental principle of reciprocal interweaving in the ontogenesis of the upright posture. Reciprocal interweaving represents a mode of ontogenetic development which provides the structural basis for the physiological mechanism of reciprocal innervation. The principle of reciprocal interweaving has wide scope in the interpretation of ontogenetic sequences. The principle may be formulated as follows: The organization of reciprocal relationships between two sets of interacting functions or motor systems is ontogenetically manifested by more or less periodic shifting ascendancies of the component functions or systems with progressive integration and modulation of the resultant behavior patterns.

sudden, but the earlier transitions bespeak a long and tedious phyletic history. For some six months the prone infant fails to progress even though at advancing ages he thrusts his knees, extends his legs, and assumes froglike attitudes. In due course he pivots, but with no locomotor advance. Later he crawls upon a grovelling abdomen. Still later he assumes a creeping stance, resting on hands and knees. At one stage he combines creep and crawl; at another he regresses; at still another he rocks, going neither backward nor forward. At about forty weeks he pulls himself to a standing position, by grasping a support. By eighteen months he usually becomes an independent runabout, but his postures and locomotions still show primitive traits (*11*).

It would be difficult to establish a chronometric recapitulatory parallelism between racial and individual stages. Eyes and hands have been given a double priority in the ontogenetic sequence. Yet there are certain suggestive correspondences between the organization of eye-hand coordination and that of general body control. At twenty-eight weeks when the hand still functions in a palmar, not to say paw-like, manner, the infant can sit erect only momentarily. At forty weeks when he rises to his feet by a brachiate pull, the digits of the hand are becoming functionally specialized. The American infant at this age is under an irrepressible compulsion to poke, to pry, and to probe with his index finger, which he uses as though it were a tool, as indeed it is. He uses his finger as an awl to thrust, as a lever to pry, and, with the now opposable thumb, as a pincer. Pincerwise he plucks the end of a string and instrumentally uses the string to pull a distant object into the scope of his ceaseless manipulation. He is already an elementary tool user. By the age of two he will have partly mastered one feeding utensil; he will be able to feed himself with a spoon, keeping the bowl right side up as he puts the spoon into his mouth.

In manipulative and exploitive behavior, the infant displays considerable resourcefulness. Despite his tender age, he demonstrates an extraordinary capacity for original activity and discovery. A baby is thus seen to be, not only the embodiment of a future adult, but also a generic embodiment of the venerable past of the human race. His growing nervous system is the carrier of an immense series of evolutionary adaptations, by means of which the race has consolidated its most essential achievements. These achievements are now the common property of mankind, but once they were creations. The evolution of human infancy has in itself been a creative process. The human infant as the current custodian of that process revives in telescoped compression some of this immemorial creativity.

LANGUAGE AND THOUGHT

Thus far we have considered chiefly the sensori-motor equipment by means of which the infant manipulates spatial relationships. The genesis of his thinking must be sought in this same equipment and the uses to which it is put. His action system develops as a unit, and both his practical and conceptual intelligence is rooted in prehensions, manipulations, and locomotions. Even his symbolic apprehensions (a semantic pun!) may be traced to sensori-motor contacts with the concrete.

Language, therefore, has a motor basis. Primitive language is mediated by postures, by facial expression, by manual gestures, and by vocalizations. Under the impress of culture the vocalizations become articulate, and the child learns to speak. Ultimately his words become vehicles of thoughts and even of trains of thought. His linguistic and intellectual acculturation, however, is limited at every turn by maturational factors.

The manner and the order in which a child acquires speech reflect stages and patterns of neuromuscular maturity. At four weeks of age his utterance, apart from crying, is restricted to small throaty sounds. At eight weeks he vocalizes single vowel sounds (*ah, eh, uh*). At twelve weeks he chuckles; at sixteen weeks, laughs; at twenty weeks, squeals. By twenty-eight weeks he usually is capable of making polysyllabic vowel sounds and a consonantal *m-m-m*. By the first year he imitates sounds, and has a word or two in his vocabulary. At fifteen months he frequently uses a jargon which seems formless, but is configured by inflections and rhythms. The jargon is a developmental matrix for words which ordinarily begin to multiply in the period from eighteen months to two years. At two years jargon is usually being displaced by three-word sentences, including the use of pronouns. At three years the child begins to use prepositions and plurals with some facility.

The foregoing sequence has ontogenetic import. The ages assigned are, of course, approximate and subject to individual variation. The order of emergence of the language abilities, however, is of developmental significance with respect to both expression and comprehension. A recent study of the speech production of preschool children at the Yale Clinic of Child Development has shown indubitable growth trends in the period from eighteen months to fifty-four months of age. The correct production of each of the consonant and vowel sounds does not proceed from age to age in gradual advance toward specificity, but shifts with repeated regressions and progressions. The mastery of consonants in terms of phonetic placement progresses from labial to glottal to postdental to labial-dental, that is, from front to back to middle. Vowel sounds progress from back to front to middle. Maturational rather than environmental factors account for such trends (*12*).

Thought might be defined as a manipulation of meanings. Words whether spoken or unspoken are devices for facilitating such manipulation. But when an infant or child manipulates objects in a meaningful manner, even without overt or inner speech, he may nevertheless be thinking. Primitive thought in the race was on a similar nonverbal level. The thoughts of the growing child are variously passing through developmental stages of egocentric concreteness, specific naming, conceptual generalization, judgment, animism, magic, syncretism, reasoning. Child logic, as Piaget has brilliantly shown, is a subject of infinite complexity which involves problems of genetic psychology and even of epistemology. Here we simply wish to suggest that the mental growth of the child is basically obedient to dynamisms which are the end product of evolution. He does not in a semantic sense relive the thoughts and experiences of his remote ancestors, but he probably ascends to sophistication by comparable dynamic steps and mechanisms. Indeed, if the knowledge were available, we might well find that the ontogenetic development of general intelligence most completely duplicates the phyletic modalities of evolution.

Even our highly technologic culture modernizes the contemporary child only by slow degrees. Although he begins to ask How and Why questions at four, five, and six years of age, he still has much difficulty in distinguishing between fantasy and reality. At these ages he has a strong interest in magic. He draws simple rational deductions, within the narrow limits of his experience, but he may be quite unable to explain how a bicycle operates. By the age of ten years, however, he thinks more readily in terms of general mechanical causes. He is less naïve; his errors of interpretation are fewer. His modes of thinking and his attitudes toward cause and effect have become truly scientific in quality.

We detect a developmental gradient in the typical reactions to the Santa Claus myth. Up to the age of two-and-a-half years the physical Santa is commonly feared. Most three-year-olds are aware of Santa long before they are aware of God. The four-year-old is a true believer and accepts every detail of the myth. The five-year-old embraces the realism of Santa's clothes, his laugh, his reindeer. The six-year-old believes with emotional intensity. If he has a lively mind, he imagines not only old Santa himself, but Santa's wife, home, workshop, and the ledger in which are enrolled the names and deeds of good children. The reflective seven-year-old has moments of skepticism, or rather, moments of constructive criticism. He may repudiate the details but adheres to the core of his faith. At age eight the notion of Santa Claus is more etherealized, but by no means surrendered. By age ten the Santa myth has been generally abandoned and, in well constituted children, probably without psychic trauma. The ten-year-old has become less naïve and more rationalistic. He ascribes natural origins and natural processes to nature and to man, and over the cosmos he may be erecting a supreme deity. His interest in magic has greatly diminished. He has attained a preliminary stage of maturity where, at a juvenile level, he can combine science and religion in a simple "philosophic" outlook (*13*).

To what extent he will continue in later years to think abstract thoughts and to elaborate ideas, will depend primarily upon the growth potentials of his nervous system. There is an embryology of behavior which may continue even beyond the traditional chronologic limit of maturity. The nervous system not only registers and organizes the past experience of the organism, but brings into being new thoughts and new insights. Such creative acts are acts of growth in the sense that they depend upon the capacity of the neurones to continue an embryonic type of development. In this manner, some of the plasticity of early infancy is prolonged into the later sector of the life cycle.

THE INTERPERSONAL SELF

It remains to inquire, at least briefly, whether the developmental mechanisms already described operate also in the organization of the child's personality — his emotional attitudes, his morals, his social behavior. Having emphasized the unity of the action system we begin with the premise that his "self," his individuality, is part and parcel of that action system. It is an organic product of growth, in a world of things, and more especially in a world of persons. From the moment of birth the human infant feels the impacts of personal care and ministrations. He is an individual, but he is not an encapsulated ego. He soon begins to sense the unremitting care which he receives. He senses it through passive touch, through hearing, but above all through vision. If he did not establish countless contacts with other human beings he could scarcely acquire a personality recognizable either to himself or to others. The make-up of his personality depends upon the interpersonal relationships which he experiences from day to day and from age to age. His self is of necessity interpersonal in many aspects of its developmental history.

No two infants were ever born alike. No two infants were ever reared alike. The individual differences which distinguish infants, therefore, have a double derivation — the genes of ancestral inheritance, and the endless variations in the personalities which constitute families, schools, and communities. However, no infant is so individual that he ceases to belong to his species and to a racial stock. Although he is sensitive to cultural impress, he has a biological equipment which sets limits to that impress and which also determines the directions, the modalities, and the intensities with which he reacts to his personal environment.

In sketchy outline it is possible to indicate the maturational stages whereby the growing self takes shape through interaction with other selves. The age levels which will be designated are not to be taken too rigidly. They are, however, based on observations of numerous children, and suggest typical trends. As early as the age of four weeks the infant reacts to social overtures by a reduction of general activity; at eight weeks his face animates to the point of smiling; at twelve weeks he both vocalizes and smiles in social response. At sixteen weeks he is capable of spontaneously initiating a social smile, and he displays recognition signs on the sight of his mother. At twenty-four weeks he begins to discriminate strangers, and at thirty-two weeks he may withdraw from them. He soon exhibits a remarkable perceptiveness in reading facial expressions. Toward the end of the first year, he participates increasingly in two-way nursery games.

These games, from Peek-a-Boo to rolling a ball back and forth, set up a to-and-fro reciprocity. The situations are simple but they are in accord with the universal dynamism of development which continues throughout the period of childhood. Sometimes the dynamism accentuates the child's ego; sometimes it accentuates the opposite partner. The accents vary with age as well as temperament. At two years of age the child calls himself by his own name, and shows a new sense of possessiveness. At two-and-a-half years he uses the pronoun "I" with imperiousness. He does not have himself well in hand, and has difficulty in distinguishing between mine and thine. He is discovering a new realm of opposites. Life is no longer a one-way street as it was at eighteen months, but is charged with double alternatives, and he finds it hard to make simple choices and decisions. This is essentially due to his immaturity, for at the age of three years he will take pleasure in making voluntary choices which lie within the range of his ability. Meanwhile, because of his bipolar confusions, the two-and-a-half-year-old tends to be variously impetuous, hesitant, "contrary," dawdling, defiant, or ritualistic. He needs skillful guidance, which is more readily given if one is aware of the developmental mechanisms responsible for this transitional stage of lessened or loosened equilibrium.

The three-year-old is in much better control of himself. His behavior is more predictable, more amenable. He has attained more power in judging and choosing between two rival alternatives. He does not insist on rituals to protect himself. It is possible to bargain with a three-year-old because he has a more balanced comprehension of two sides of a transaction. He has more flexible interpersonal relations, not only because he has had more experience, but also because his action system is for the time being in a more mature and better working equilibrium.

The foregoing comparison will serve as an illustration of the kind of ontogenetic shifts in emphasis and balance which constantly recur throughout the cycle of growth. This shifting imparts a spiral-like recurrence and reorganization with regroupings at ascending maturity levels. Viewed in perspective, however, the onward advance of maturity traits becomes apparent. At three-and-a-half years of age, there is a return to some of the bipolar characteristics of the two-and-a-half-year-old period, but on a higher level. It is not a regression but another lessening of equilibrium which expresses itself in a transient instability and tentativeness. The four-year-old is in an expansive phase of development manifested in bragging, boasting, and a tendency toward out-of-bounds behavior. The five-year-old is more self-contained, better integrated. He takes himself and others more for granted. He invites and accepts supervision. His ready obedience makes this period of relative equilibrium seem like a golden age.

But at six years of age and earlier the self-containedness gives way to new developmental symptoms. The child's behavior becomes at times brash and combative as though he were at war with himself and the world. He is indecisive, over-demanding, and explosive; he is also at other times engaging and companionable. He has strangely contradictory spurts of affection and antagonism. These characteristics naturally vary from child to child, but they occur with sufficient frequency and intensity to warrant the conclusion that the period of second dentition is one of great complexity in the ontogenetic organization of the maturing individual. In many respects the behavior symptoms at this stage are reminiscent of the two-and-a-half-year-old transitional disequilibrium. There is an increase of somatic complaints; the mucous membrances become more vulnerable, allergy responses are high, motor adjustments are often clumsy and headlong. Such manifestations can scarcely be ascribed to cultural or psychogenic factors. On the contrary, they point to deep-seated maturational mechanisms. Needless to say, these developmental changes do not occur abruptly, but when the successive annual zones are compared with each other as sectors of a cycle, the presence of an underlying ontogenetic process is revealed.

At seven years there is a quieting down. The seven-year-old is much less impulsive than he was at six years. He tends to be pensive. In a sensitive manner he seeks friendly relations with his companions and his teacher. He is in an absorptive, assimilative phase. If he is articulate, we may find that in his more subjective moods he has a fear of losing his own identity. He worries that his mother, teacher, and playmates do not like him. He may entertain a strange fear that he is merely an adopted child. He tends to protect himself by withdrawal.

In mild degree these are relatively normal symptoms at this transitional level of maturity. They reflect the *modus operandi* of a normal psychological growth process. When the symptoms are extreme and exhibit a marked schizoid trend, which persists at other inappropriate age levels, the behavior may indicate psychopathology. This is mentioned in passing, to suggest that child psychiatry must be based upon a knowledge of the normal ontogenetic patterning of behavior.

The eight-year-old adjusts more robustly to adults and is beginning to look more like one, for there are somatic changes involving his face and facial expression. He is less brooding than at seven, more receptive to the responses of others. He fraternizes readily with his companions, but he watches adults with a new and critical alertness. He resents being treated as a child, wants to be an adult, and wants the adults to be part of his world. He is unquestionably in an expansive phase, which enlarges the interpersonal scope of his self.

At nine years the sense of self comes into clearer focus. There is a new kind of self-consciousness, manifested in self-appraisal, in greater self-reliance, but above all in increased power of self-motivation. Typically, a normal nine-year-old wants to succeed; he works hard for a reward; he works to perfect his skills. He tends to be fair-minded and responsible.

The ten-year-old displays greater self-possession. He takes his tasks and responsibilities more in stride. He can be relaxed and casual as well as alert. His whole organization is less channelized; his attitudes are more flexible; he is more responsive to slight cues. This makes him very receptive to social information, to broadening ideas and prejudices, good and bad. He is capable of loyalties and of hero worship. In a favorable culture, in a favorable family, he takes kindly to liberalizing ideas of social justice and social welfare (*14*).

Ontogenetically speaking, ten, like five, is a nodal age. A typical ten-year-old is in good equilibrium, and in good touch with the adult environment. His individuality is now so well defined, and his interpersonal self is so much more mature, that he can be regarded as a pre-adult, although ten years of adolescence lie ahead — a whole decade more of biological infancy.

THE TASK OF A SCIENCE OF CHILD DEVELOPMENT

The child comes by his mind in the same manner in which he comes by his body, that is, through the organizing processes of growth. According to the principle of hierarchical continuity, no sharp lines divide the three major manifestations of the growth complex: the anatomic, the physiologic, and the behavioral. A comprehensive science of child development would concern itself with all three of these manifestations and aim to bring them into closer correlation.

From the standpoint of clinical science, development is a process which yields to objective methods of investigation and diagnosis. The interaction of psychic and somatic factors is recognized. But if the mind as well as the body falls within the scope of preventive medicine and social welfare controls, chief attention must be given to the behavior patterns of the infant. His behavior characteristics constitute the most comprehensive index of his developmental status and of his developmental potentials.

The developmental examination of infant behavior can be undertaken with relatively simple techniques. Using the plain appurtenances of a crib, a table surface, and a series of test objects, it is possible to elicit a rich array of behavior patterns which reveal the organization and the integrity of the child's action system. In clinically experienced hands, a behavior examination may serve several functions, as follows: (*a*) it ascertains stages of maturity and rates of development in various types of infants — normal, subnormal, and atypical; (*b*) it yields differential diagnosis in relation to normality, mental deficiency, and specific developmental deficits and deviations; (*c*) it brings to light otherwise concealed neurologic defects and sensory impairments; (*d*) it helps to define the developmental outlook in infants suffering from various types of handicaps — blindness, deafness, endocrine dysfunctions, convulsive disorders, and cerebral palsies — devastating, selective, and mild; (*e*) it contributes objective information relative to emotional and personality traits of the infant and throws light on parent-child relationships; (*f*) it implements a periodic type of developmental supervision of normal as well as handicapped children (*15*).

The demands for such supervision will grow more intense with the elaboration of health services already under way. The progress of the life sciences, which deal with the biochemistry, the biophysics, the physiology, and the pathology of growth, will lead to more systematic protection of infant development. The world-wide study of cancer as a form of atypical growth and the brilliant researches of experimental embryology will almost certainly yield important knowledge for the control of normal organic growth. With more knowledge there will be refinement rather than loss of human values (*16*).

One task of science is to make the nature of human infancy more intelligible. We are still profoundly ignorant of the mechanisms of psychological growth. Many of our ideas about child behavior are essentially pre-Darwinian. The concept of evolution as it applies to the race is much more widely appreciated and accepted than the concept of growth as it applies to infant and child. We still approach the problems of child care, child discipline, and even of child education in terms of one-dimensional absolutes without awareness of the added dimension of development.

This lack of awareness constitutes a genuine cultural lag. Our culture at present is more rational about the physical universe than it is about children. We freely acknowledge the laws of nuclear energy, the gradients of the spectroscope and of frequency modulation, but we scarcely recognize that the behavior of the growing child is equally subject to laws, to gradients, and to sequences.

The race evolved, the child grows. The enormous evolution of the hemispheres of the human brain has made possible the astounding disclosures of modern technology. But the nervous system of the infant of today cannot be dated ahead. It is built on a conservative model which nature has not discarded — a model determined by genes no less than by culture. A science of child development is needed to clarify the limitations as well as the potentialities of this all too human nervous system under the impacts of a technological culture.

The physical consequences of this culture are even now threatening the developmental rights of children and the normal relationships between children and adults. It has been suggested that if science is incapable of developing moral techniques to counteract this threat, "the split in modern culture goes so deep that not only democracy but all civilized values are doomed."

Here, then, lies the task of the life sciences. A science of man under heightening social pressures will need to define the mechanisms, the principles, and in some measure the very goals of child life and of family life. Such a science would be instrumental, and in a way even technological, but it would also be humanistic. It would have an integrity of its own, and be in itself a value and a creator of values.

At any rate, we cannot conserve the mental health of children, we cannot make democracy a genuine folkway, unless we bring into the homes of the people a developmental philosophy of child care rooted in scientific research.

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The Evolution of Mind

NORMAN L. MUNN

The author of this article draws upon the research of several psychologists to give a well-organized account of some major steps in behavior evolution from ant to man. This account points up the tremendous superiority of man's behavior equipment in comparison to that of all other animals. The emergence of more versatile behaviors as we proceed up the animal scale parallels the development of more complex nervous systems. Add to the fact of this parallelism the rapidly increasing knowledge concerning the importance of brain functions per se, and we begin to see the significance of the role of that organ in the integration of behavior and communication within the body. Munn refers to the work of the Hayeses in training a chimpanzee (see selection 34) and shows the importance of symbolic language skill in differentiating man from the lower animals.

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NOTE: Two figures have been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the author's permission.

No one has ever seen a mind. A surgeon cutting into the brain sees only nerves and blood vessels; to learn what is going on in the brain he must ask the patient. An electroencephalogram (recording of brain waves) can show whether the brain is thinking, but it tells nothing about what is being thought. Only through communication, language, can we get any sort of direct picture of the workings of the mind. We are therefore under a certain basic handicap in attempting to fathom the mental life of animals below man.

There is an ancient Chinese story which illustrates the ingenuous human attitude in this matter. It runs:

Chuang Tzu and Hui Tzu were standing on the bridge across the Hao River. Chuang Tzu said, "Look how the minnows are shooting to and fro! How joyful they are!"

"You are not a fish," said Hui Tzu. "How can you know that the fishes are joyful?

"You are not I," answered Chuang Tzu. "How can you know I do not know about the joy of the fishes? . . . I know it from my own joy of the water."

Modern psychology does its best to suppress the intuitive, or anthropomorphic, approach and seeks to find out how an animal's mind works by studying its behavior. As everyone knows, there has been a vast amount of experimental work on animals of all sorts, testing their responses in controlled situations to learn about their mental processes. My purpose is to review some of these experiments and see what light they shed on the evolution of the mind.

Here is an ant. It exhibits an extremely complex pattern of behavior. Does this signify intelligence or is the behavior purely automatic? We observe, for example, that the animal attacks every foreign ant that enters its territory. Does it recognize the newcomer as a stranger and anticipate a potential danger to its own group? Or is it merely reacting automatically to a strange odor from the newcomer? As a test we extract some juice from a strange ant and smear a little of it on a member of the ant nest. When the ant returns to its own nest, its nest-mates become greatly excited; they quickly attack and kill it. No, in this respect the ants are not acting with intelligence but simply as automatons, responding blindly to an odor in accordance with mechanisms which nature has built into them.

Nevertheless ants are capable of learning: their behavior can be modified. If we had enough patience, we might even teach them not to attack ants with a strange odor. T. C. Schneirla, the well-known student of ant behavior, found that ants could master a maze test, learning to avoid blind alleys and get home without error.

Learning of all sorts of mazes by many different animals at various levels of evolution has demonstrated that practically all animals are modifiable to some degree. There is a fairly regular sequence of ability; as we go up the scale, we find the higher forms learning faster and mastering more complex mazes. The ant is rather far up the ladder.

When we get to the mammals, the maze becomes an inadequate test of intelligence. The learning problem (making the proper turns in the proper sequence) is just too simple. In this sort of learning rats can beat college students, and have done so repeatedly. So it is apparent that at the rat level and above we must make our tests more subtle, because new mental abilities beyond sheer modifiability begin to emerge.

The first of these is the ability to think of something in its absence — that is, to represent or symbolize a stimulus which was present but is now gone. This capacity is usually examined by a delayed-reaction test. In one such test the animal is released in a room with three identical exit doors. The animal first learns that if it goes to the door where an electric bulb is lighted (any one of the three may be turned on), it can go through to a passage to food; if it goes to either of the other doors, it receives a shock from an electric grid. After the animal has learned to choose the lighted door every time, it is given the delayed-reaction test. The subject sees the light at a certain door; then the light is turned off and the animal is held in the restraining cage for a certain interval before it is released. How good is it at remembering where the light was? A rat or a dog will go to the correct door — so long as it is allowed to point its head toward this door while it is waiting, and can follow its nose straight to the door after it is released. But if we turn the animal around, so that it loses its muscular cues, the rat or dog cannot remember the position of the light.

However, a raccoon, comparatively a very wise animal, passes this test with flying colors. It does not need to point: it will pace up and down in its restraining cage until released and then go directly to the door where the light was. Something other than muscular tensions, something in the raccoon's nervous system, must represent the absent light. This memory in the raccoon case lasts for about 25 seconds.

Experiments in which parts of the brain of an animal are removed clearly show that this something involves the brain's frontal lobes. If both of the frontal lobes are removed or damaged, the animal fails in the delayed-reaction test. But lesions in other areas of the brain do not seriously impair performance on the test.

As we ascend the scale from rat to man, animals are able to perform delayed responses of increasing complexity. A monkey, for instance, can make a delayed choice correctly without preliminary training. Directing the monkey's attention to a pair of inverted cups, we slip a piece of lettuce under one of them and then hide the cups with a screen or take the monkey for a walk. After a certain interval the animal is allowed to go to the cups; he gets the lettuce only if he turns over the correct one. He must remember whether the lettuce was placed under the cup on the right or the left (he gets no help from the odor because both cups were smeared with lettuce juice). Some monkeys can remember the correct cup consistently even after a delay of 24 hours.

Now we make the problem more complicated by presenting several pairs of cups and placing food under one cup of each pair — either the right or the left at random. The animal, after the delay, is released to go from pair to pair, selecting the food cup in each. Monkeys and chimpanzees were compared on this test. The chimpanzees of course far surpassed the monkeys, both in accuracy and in span of memory.

The most interesting thing about this experiment is that the monkeys and chimpanzees remember not only *where* the food is hidden but also *what* was put under the cup. If we put a banana beneath a cup and then surreptitiously replace it with lettuce during the delay interval, the animal, upon picking up the cup and finding lettuce where he expected banana, will hunt around for the missing banana and may have a temper tantrum.

The ability to represent or symbolize an experience when the stimulus is absent is an extremely important step in mental evolution: it prepares the way for understanding and thinking. Once the brain can *think of* an object or event, it can begin to put two and two together, to solve problems by reasoning instead of by overt trial and error.

Here is a test which illustrates the point. The animal is placed behind a wire mesh or glass screen through which it can see a dish of food on the other side. To reach the food it must go around the barrier. A chicken or a rat, put to this test, fails to understand the situation: it will claw at the barrier again and again in an effort to get at the food. Finally it begins to run about at random and may accidentally come upon the food. If we now put the animal back behind the screen, it will repeat its attacks on the screen but this time will give them up sooner and find the food in less time than before. After several trials, the animal eventually learns to run immediately around the barrier to the food.

A monkey or a chimpanzee, on the other hand, quickly sizes up the situation. It goes around the barrier to the food without delay and without false moves. A primate can work out the situation implicitly within the brain: it can put two and two together and observe what leads to what. That is to say, it learns by observing as well as by acting. These close relatives of ours have what Wolfgang Köhler, the famous Gestalt psychologist, calls insight.

The extent of their insight must be tested with more complex problems. A banana is placed high above the head of a chimpanzee in a cage. Various possible aids to reaching the banana are present — sticks, boxes, a hanging rope. Is a chimpanzee capable of inventive use of them? Indeed it is. Chimpanzees have been known to stack boxes and climb up on them, to use a long stick much as a pole-vaulter does, to reach the banana by swinging on a rope Tarzan fashion, even to insert one bamboo pole into the end of another to make a stick long enough to reach the food. They have been known to lick a piece of straw so that ants will stick to it and then lay it on the ground, wait till the insects have swarmed over it and lick off the captured ants.

Sometimes chimps even outsmart the professor. Robert M. Yerkes liked to tell about the chimp to whom he presented a problem which he thought had just three solutions, only to have the animal solve it by a fourth way which had never occurred to the professor. Köhler describes a similar experience. He had provided some boxes and various other objects by which a chimpanzee might reach a banana hung nine feet high. But the chimp, after looking over the situation, took Köhler by the hand, led him to a position beneath the banana and scrambled up on the professor's shoulders to grab the banana!

Let us proceed to a more subtle problem, devised by the late Walter S. Hunter. It is a maze, but of a very sophisticated type. The apparatus consists of a T-shaped arrangement of alleys. The subject starts at the foot of the T, goes to the head and, turning either into the right or left arm of the T, returns by a passage to the starting point. Now to win the reward (and avoid electric shocks for making the wrong turns) the subject must go through the run four times, making a right turn at the head of the T the first time around, another right turn on the second trip, a left turn on the third trip and another left turn on the fourth trip. In other words, the animal has to learn that the correct sequence is right, right, left, left. There are no light cues, no muscle cues, no signs of any kind to tell him what the proper sequence may be. In a sense the animal must learn what *principle* is in the experimenter's mind. He must figure this out by implicit processes in the brain, using symbols to represent the "trials."

On this test a rat fails completely. Even after 2,000 trials it still has only a chance percentage of successes in its runs. A raccoon or a cat solves the problem in from 500 to 800 trials. A monkey or a chimpanzee learns the correct sequence in 100 trials, more or less.

Since there is nothing in the layout to give the answer by inspection, a human subject has to start out with trials as the lower animals do. But it takes an adult only a few trips to catch on; the subject suddenly exclaims, "Oh, I get it. I'm supposed to go twice to the right and twice to the left." The number of trials an individual subject needs correlates fairly well with his I.Q. as measured by written intelligence tests.

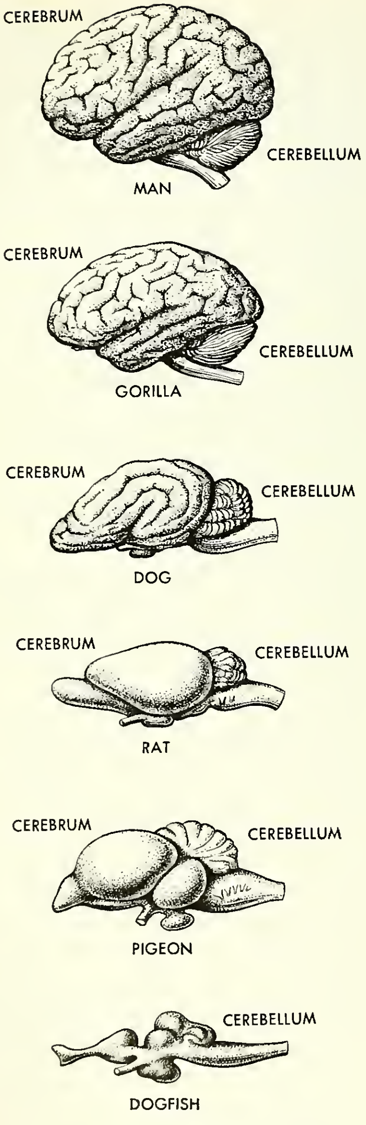
A child under three years of age cannot solve this problem. Children do not surpass animals on the test until they begin to verbalize it. Obviously verbalization is not essential, for animals could not solve the problem if it were, but it certainly helps. Words are symbols *par excellence*. They can represent experiences, and they can bridge gaps to establish relations.

Here, then, is another important stage in the evolution of the mind — by far the most important. A chimpanzee, intelligent as it is (in its first year or two it shows more intelligence than a human baby), simply cannot master language. It can be taught to speak a few words, but each word takes months and five words seem to be about its limit. Moreover, it never gets to use words as we use them. It speaks a word only to get what it wants and only on command; it voices words only to its teacher, never to other people or to another chimpanzee; it never puts two words together. It speaks reluctantly, after all other efforts to get something have failed, as if speaking were extremely painful.

In fact, it does not speak to its own kind; there is no evidence of a chimpanzee language. Its spontaneous vocal noises are called forth only when it is emotionally aroused, and apparently they have no linguistic significance beyond alerting another chimpanzee.

This had always been a great mystery: Why do the almost-human apes, though capable of mental symbolization, fail to cross the bridge to speech? They have sufficient vocal equipment — can make a wide range of sounds — but words, one might say, fail them. We begin to get some light on the reasons when we look at the ape's brain. The brain of a full-grown chimpanzee weighs only about one pound — one third as much as ours. The ratio of its brain weight to its body weight is one to 150; in human beings it is about one to 50. That is to say, with a body as large and complex as our own, the chimpanzee has only one third as much brain to manage it. Furthermore, in the ape's brain the frontal area, which is concerned with associations and symbolic functions, is much smaller in relation to the rest of the brain than ours. It seems to lack entirely the section in the left frontal lobe known as Broca's area, a part of the human brain known to be involved in speech.

An ape has no spontaneous babble of sounds, as a human baby does. This was clearly illus-



Cerebrum and cerebellum of six species are compared in these drawings. The brains are not drawn to the same scale.

trated by the famous female chimpanzee named Viki, who was reared exactly as a child in the home of Keith Hayes and his wife, at the Yerkes Laboratories of Primate Biology. Mrs. Hayes's popular book, *The Ape in Our House,* gives considerable attention to Viki's language training. Viki never babbled: she was silent except when emotionally aroused. Since she had no urge to talk, it was decided to make Viki speak for her supper, as a dog might be taught to bark for it. When she made a worried little sound ("oo oo") on being deprived of her milk, she was rewarded with the milk. After five weeks of such training she emitted one day a loud "ahhh," accompanied by facial contortions. Thereafter she would make the "ah" sound when commanded to speak. Mrs. Hayes then trained her to say "Mama" by pressing her lips together and releasing them as she said "ahhh" for food. After a few weeks Viki was saying "Mama" by herself. The word "papa" was laboriously added to her vocabulary after she had learned to imitate a Bronx cheer. Then Viki learned to say "cup" by repeating the sounds "k" and "p" in rapid succession. Later she added "ch," to ask for a drink, and a click of her teeth, asking to be taken for a ride in the car. But she never used any of her five "words" for social purposes or for egocentric expression. She "spoke" only when there was no other way of getting what she wanted. She gave no evidence of insight into the meaning of language.

How different it is when children learn language! The sudden insight which is part of this process was most dramatically revealed by the experience of Helen Keller. Anne Sullivan, her teacher, told how Helen discovered her first word, as it was spelled out in her hand. One morning during her seventh year the child asked the name for water by pointing to it and patting her teacher's hand. Miss Sullivan spelled the word in the manual alphabet. Later, when they went out to the well for water, the teacher made Helen hold her mug under the pump spout while she spelled "w-a-t-e-r" into the child's free hand. "The word," says Miss Sullivan, "coming so close upon the sensation of cold water rushing over her hand, seemed to startle her. She dropped the mug and stood as one transfixed. A new light came into her face. She spelled 'water' several times. Then she dropped on the ground and asked for its name and pointed to the pump and trellis, and suddenly turning round she asked for my name. I spelled 'teacher.' Just then the nurse brought Helen's little sister into the pump-house and Helen spelled 'baby' and pointed to the nurse. All the way back to the house she was highly excited, and learned the name of every object she touched, so that in a few hours she had added 30 new words to her vocabulary." The next day Helen was like "a radiant fairy," going from object to object and naming it.

The discovery that everything has a name is "like an intellectual revolution," as the German philosopher Ernst Cassirer pointed out in his *An Essay on Man*. "The child begins to see the world in a new light. It has learned the use of words, not merely as mechanical signs and signals, but as an entirely new instrument of thought."

This insight is beyond the reach of any animal. Even the most intelligent subhuman animal reacts only to sounds, not to the meaning of words. The late Edward Lee Thorndike once demonstrated the point with an experiment on his cats. He had trained them so that when he said, "I must feed those cats," they dashed to the food box, even when he put no food in it. One day, to test their understanding of his words, he exclaimed at the cats' meal time: "Today is Tuesday." The cats instantly sped to the box. The words "My name is Thorndike" evoked the same response.

"What's in a name?" asked Shakespeare. "A rose by any other name would smell as sweet." Perhaps, but the naming of things is the great difference that separates the human mind from animal minds. Somehow or other man's brain evolved to the stage where he was able not only to think of things (through images or whatever animals use) but also to see the value of using names for them. With language, the human species entered a new world, began to think more clearly, became capable of reflecting on the past and penetrating the future, gained mastery of the environment. The future of infrahuman animals lies with nature, with mutations and natural selection, but man's future is largely under his own control, thanks to the gift of language.

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Animal Intelligence

CARL J. WARDEN

Ability to learn, remember, and to solve problems are accepted signs of the intelligence of human individuals. These same criteria can be adapted to the rating of intelligence of lower animals, as Dr. Warden shows. He describes the logic and the design of experiments which determine the intelligence level of various species. Language — a tool which man alone possesses, and which is emphasized in other selections — figures in Warden's account of the multiple-plate problem. Common observation of the brightness of primates is verified by these experimental tests, but many people are surprised at how well the pig rates. The dog is brighter than the cat, and the horse is not as high on the scale as some would expect. In general, intelligence level is related to neural development, manipulatory skill, and specialization of sense organs. Thus, intelligent actions are found to rest upon stimulus-response equipment.

Dr. Warden, now retired, was professor of psychology at Columbia University and director of its animal laboratory where many pioneering studies were conducted. This article appeared in the June, 1951 (pp. 64–68) issue of *Scientific American* and is reprinted by permission of the publisher.

Man has never doubted that he is the most intelligent member of the animal kingdom, but he has been in some dispute as to how to rate the relative intelligence of his subhuman inferiors. Many great thinkers have been interested in the question of whether animals reason and how much intelligence they possess. The first to deal systematically with the subject was Aristotle. In his *Historia Animalium* he contended that the dog, the elephant and some of the other higher mammals approached the mental level of the human child. At the other extreme, Descartes argued that even the highest forms below man are only rather complex living mechanisms with little or no real intelligence. Opinion has fluctuated between these poles: in modern times Charles Darwin and his followers have tended to agree with the anthropomorphic view of Aristotle, while the physiologist Jacques Loeb and his disciples supported the mechanistic interpretation of Descartes.

Darwin, who sought to support the doctrine of evolutionary continuity by showing that the animals akin to man possess the rudiments of human intelligence, based his case largely on stories of unusual mental exploits by the higher animals. At the end of the 19th century comparative psychologists rejected this anthropomorphic, anecdotal approach and began to study the question by objective experimental methods.

Intelligence may be defined as the capacity of an organism to learn to adjust successfully to novel and difficult situations. It involves the ability to solve new problems by drawing on past experience. Those who consider that animals below man are mere mechanisms place great emphasis on a supposed distinction in methods of learning, as between human beings and animals (the word animals will be used here to mean the nonhuman ones). In animals learning is mainly by trial and error. When a cat, for example, is confined in a latched box that acts as an obstacle preventing it from reaching food outside the box, it tries all sorts of measures to solve the problem. It claws at various parts of the box, attempts to shake the box to pieces, tries to push the door open, and so on. After many such fumbling trials, it eventually learns to throw the latch and open the door without fumbling. Man, on the other hand, can solve such simple problems almost immediately, with a minimum of trial and error. This "insight learning" is commonly supposed to show a qualitative difference between men and animals, but actually some of the higher animals are capable of it. Moreover, man often uses the trial-and-error method, particularly in forming new motor habits such as typing or playing golf and in solving mechanical puzzles. Hence it would seem that the true measure of intelligence is the capacity to learn, regardless of the method involved.

We must distinguish, however, between adjustments that are learned and those that occur naturally without involving learning. The latter include responses of the simple reflex type and the more complex activities commonly called instincts. Reflexes, which are set off automatically by appropriate environmental stimuli, do not involve the brain; hence they are clearly below the level of intelligent behavior. Similarly such basic instinctive behavior as reproduction, nest-building, protection and food-searching also comes into play without learning. At the proper time the animal simply does "what comes naturally." Take the nest-building instinct, for example. In early spring, when an outpouring of sex hormones into the bloodstream gives birds a strong sex drive, they pair off, pick out a well-protected place for the nest and begin to build it. They construct it on a plan that is peculiar to their own species, selecting certain materials and rejecting others. When the nest is finished, it turns out to be just the proper type for the given species of bird. To the layman it looks like an intelligent job from first to last. But birds hatched in an incubator and never allowed to see their parents build a nest will instinctively build one of their own species type when they grow up.

Aristotle, observing that some spiders spin very complex and beautiful webs, ascribed this ability to intelligent designing, like that of a human weaver. He failed to see that each species of spider is able to spin only a certain type of web. The reason why instincts appear to involve intelligence is that they are highly adaptive; evolution has provided each species with certain urges nicely designed to help it survive. Instincts are wonderful devices that enable the animal to carry on the main business of life without the bother of having to learn and think.

The general intelligence level of an animal depends in the first instance on the complexity of its body organization and the relative size and specialization of its brain. The more specialized its sense organs, nervous system and appendages, the greater is its sensitivity to stimuli and the better it is able to integrate its activities and manipulate its environment. The single-celled amoeba has a very limited set of natural esponses and can learn only simple acts. After number of trials it can learn to turn directly way from an annoying beam of strong light hrown across its path. The common anglevorm, much more complex in structure and reponse system, can learn a T-maze rather readily. Still more complex organisms, such as the ant nd other insects, are able to learn complex mazes vith a dozen or more blind alleys or culs-de-sac. rough, convenient measure of intelligence mong vertebrate animals is the ratio of the veight of the brain to that of the spinal cord, the asic reflex center. In fishes the brain weighs ess than the cord; in the cat it weighs four times s much as the cord; in the monkey the ratio is ight to one, and in man, 50 to one. This inrease in brain weight is accompanied by a coresponding increase in specialization of the brain nd its functions.

From these purely biological facts we can say hat the mammals, the animals that suckle their oung, rank highest in intelligence, and among the higher mammals the ranking is: (1) the primates, including the monkeys and the great apes; (2) the carnivores, which include the dog, cat, fox, raccoon, lion, tiger and bear; (3) the ungulates, or grazing animals, among which are the elephant, horse, pig, cow, deer, zebra and the like.

Let us now see what laboratory tests show as to the relative intelligence of various animal species. Serious experimental work, which began about 60 years ago, has been limited largely to birds and mammals. The general plan of all such experiments is to set before the animal some task that seems suitable to the species to be tested. The drive to work at the problem is aroused by a period of fasting, and the animal is given a morsel of choice food after each trial. Several trials per day are usually given, and the series of trials is continued until the animal either fails or solves the problem. Such an experiment may run for only a few days or for weeks, depending on the difficulty of the task and the degree of progress shown.

In tests to compare the intelligence of different species we begin with a simple problem, and when this has been mastered we increase the complexity of the task by gradual stages up to the point where the problem is too difficult for the animal to master. As the tests progress, the less intelligent species drop out. The stage each species reaches before failing marks the "limit score" for that species.

One test used in the Columbia University laboratory is known as the multiple-plate problem box. The apparatus consists essentially of a large mesh cage with a small cage for food in the center and three plates in the floor. In the first stage of the test the animal is required to learn to step on one plate, located at the right of the entrance compartment in the large cage, to open the food cage and get its reward. When this act has been well learned, the animal is submitted to the second stage: it must step on two plates to open the food cage. The experimenter adds one plate at a time to the test. He trains the animal to step on the plates in a given order, reversing its direction after each three-plate sequence until it reaches its learning limit. Hundreds of trials are given at the failure point to make sure that the animal cannot master it.

The limit score for the guinea pig is one plate; for the white rat, two plates; for the cat, seven plates; and some monkeys were able to learn to step on 22 plates in the given order. A human child old enough to count presumably could go on indefinitely on such a test.

Then there is a delayed-response test. With the animal watching, the experimenter places some food in one of three cans that look exactly alike. The animal is then taken from the room and after a period of delay is brought in again to see if it can identify the can with the food in it. The animal fails the test unless it goes directly to the baited can without trying any of the others. This is a memory test in which the cue is the serial position of the baited can: was it the left one, the right one or the middle one? The scoring criterion is how long the animal can remember the correct can. The experimenter begins with short delays and increases these gradually until the animl reaches the limit of its memory span. Cats can identify the baited can after a delay of 16 hours. Monkeys can remember readily for at least 20 hours (their maximum span was not determined), and chimpanzees for 48 hours or more.

A third experiment is called the quadruple-choice test. This is perhaps more a test of stupidity than of intelligence. The animal is presented with four boxes, each of which has an open front door and a closed back door. All four boxes look alike as they are approached, but in three the back doors are locked from behind, while in the fourth the back door can be pushed open so the animal can obtain food behind it. The animal can try all four doors. The experimenter flips a coin to determine which door is to be left open on each trial, but he arranges that it shall always be one that was not open on the preceding trial. In other words, the same door is never left open twice in succession. It is obvious that under these conditions the animal cannot select the proper door except by chance. The problem is insoluble, since the correct door may be any one of the three that was locked on the previous trial. The aim of the test is to see the degree of stupidity or intelligence that the animal will exhibit in attacking the problem. The stupidest type of behavior would be always to go to the door that was correct on the previous trial and ignore the other three doors. Such a stereotyped error would mean failure on every trial. The most intelligent course would be to avoid every time the door that had been open on the preceding trial and to try only the other three doors: this would be as near a solution of the problem as could be worked out.

This test has been given to a number of mammalian species, including human beings, who were asked to press a key instead of going through a door. The stupidest performers are the rodents — mouse, rat, gopher. They almost invariably attack only the door that was open on the preceding trial. Other animals, going up the scale of intelligence, show an increasing percentage of flexible and variable kinds of response. They tend to try all the boxes, either in random order or according to a set system, such as from right to left or left to right. Such flexibility of behavior in adjusting to a new and difficult situation is one of the marks of high intelligence.

On this test the species studied ranked in intelligence as follows, from low to high: gopher, mouse and rat, horse, cat, dog and monkey. None of the animals succeeded in discovering the most intelligent possible response, namely never to try the door that was open on the previous trial. Nor did very young children, even after a long series of trials. But normal children eight years of age or older were able to draw this inference.

In general the results on these tests bear out the evolutionary and biological findings; that is, the carnivores rate higher in intelligence than the grazing animals, and the primates far ahead of the carnivores.

What are the 10 most intelligent animal species? According to the best evidence now at hand, the chimpanzee stands at the top, and the next nine are all certainly primates. The gorilla, orangutan and gibbon come right after the chimpanzee. These great apes are, of course, man's next of kin. Then there are at least six species of monkeys that rate higher than any of the carnivores.

Monkeys and apes have a very complex body organization and a superior brain and nervous system, similar in most respects to that of man. They also rank much higher than other animals in manual skills. They can use sticks to draw food beyond arm's reach into the cage, and they even learn to use a short stick to draw in a series of longer sticks until they get one long enough to reach the food. The exceptionally clever "chimps" can manipulate well enough to stack as many as five boxes under a banana hung from the ceiling, climb on top of the boxes and snatch the lure from this position. They readily learn to ride tricycles and kiddy-cars and to pull small sleds and wagons with children in them. They can be trained to manipulate a toothbrush, hairbrush, spoon and cup, faucets and ordinary toilet facilities. They can also smoke cigars and cigarettes in human fashion. A chimp can learn to operate a set of simple latches merely by seeing another do the act — this capacity to learn by mere observation has not been found in any sub-primate animal. Chimpanzees learn to accept poker chips in lieu of food as reward during an experiment, and they will cash in the chips for food by dropping them into a slot machine or "chipomat." When they have eaten their fill, they will drop in a special chip which yields a "jackpot" of chips and then store these in their living quarters for later use. A pair of chimpanzees will cooperate in trying to pull a heavy food box into their cage. The chimp has a good sense of rhythm and can readily learn to beat a bass drum in time to simple jazz music. Chimpanzees are probably the only animals that have even a crude sense of humor. Some of them learn to play practical jokes of the "hotfoot" type on human beings. There is a known case of a "spitter" chimp that would lure zoo visitors close to his cage and then shower them with saliva, and of another that liked to sling handfuls of muck at bystanders. These animals would then caper about the cage in high and noisy glee. The capacity for humor represents, in my opinion, the apex of intelligence in an evolutionary sense.

The intelligence of carnivores has been studied mainly in the dog and cat; for obvious reasons little work has been done on such wild types as the lion, tiger, bear, leopard or fox. Probably none of the wild types would rate higher in intelligence than the domestic dog and cat. The truth seems to be that wildness makes for stronger instincts, arising out of competition in nature, rather than for higher intelligence. On the tests here described the dog and cat rate next to the monkeys. In the quadruple-choice test dogs scored higher than cats. This agrees with other evidence that the dog outranks the cat somewhat in intelligence level. For one thing, the dog is willing and cooperative, whereas the cat tends to be shy and aloof. The dog also takes a greater interest in objects and people — a trait which, along with docility, is one of the marks of high intelligence.

Dogs can be taught to perform many acts on the command of the master. Some years ago I tested the famous German Shepherd named Fellow, which has the best record to date on this type of performance. His master had trained the dog to associate objects and acts with the names we give them in human language. Fellow could carry out nearly 100 acts at a verbal command, such as "Go out to the elevator and wait for me," "Go put your feet on the radiator," and the like. He could also select one named object among three placed before him, even when the person giving the order was hidden behind a screen to eliminate the possibility of giving the dog gestural cues. After I had worked with Fellow for a while, he learned to recognize me by name and would pick me out of a large audience and come to me on command of his master. Of course, dogs live in a world in which human language plays an important role, but the ability to learn as many associations as Fellow did seems remarkable indeed.

The dog can be trained to great expertness in specific situations. The "Seeing Eye" dog, after a long and rigorous training, can be trusted to lead a blind man through heavy city traffic. It learns to stop the blind man from blundering into an obstruction, even when the latter is so high that the dog itself can pass under it without harm. As everyone knows, thousands of dogs performed skillful services in the last war. They were trained to protect soldiers and military supplies, tackle enemies, carry messages and do various other jobs.

Among the grazing animals the horse, probably in part because of its grace and beauty, is commonly thought to be the most intelligent. Actually the evidence at hand seems to indicate that the horse ranks below the elephant and the pig. I believe the elephant belongs at the top of this list, and I doubt that any comparative psychologist would disagree with this rating. Although the elephant has not been tested in the laboratory because of its size, we know that it is a docile and skillful beast of burden throughout the Orient, that it can be trained to do fairly complex circus tricks and that it has a proverbially long memory for friends and enemies. In comparing the pig and the horse we are on less sure ground. On one complicated test of intelligence level the pig stands relatively high. On the quadruple-choice test the horse, the only grazing animal tested, scored well below dogs and cats. On the whole, however, I think we must wait for further experimental evidence before assigning comparative ratings to the horse and the pig. I suppose the fact that the pig stands high at all will come as a surprise to most people. Perhaps we have thought of the pig too much in terms of ham and bacon!

It is clear that we can rank animals on the intelligence scale only by rough general levels. The evolution of intelligence did not proceed in a straight continuous line, from the stupidest to the smartest animals. Each species developed its own type of intelligence, within the limits of its specific instinctive equipment and in response to the more or less specific demands of its environment.

The human level of intelligence is far higher than that of the anthropoids from which man evolved in the distant past or that of his present next-of-kin, the great apes. Man evolved a larger and more elaborate brain, the ability to walk upright and the capacity for superior manual skills. Furthermore, he also acquired the ability to develop culture and to transmit it from one generation to another by means of language symbols. The culture process was slow in starting, but once under way it operated at an increasingly rapid pace, without the need for further biological evolution. Man is the only animal that evolved the capacity and mechanism of culture. It is this fact more than anything else that sets him apart from all the other animals.

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A Day in the Life of a "Three"

CATHY HAYES

Perhaps the most famous chimpanzees have been those raised by psychologists in their own homes. The first was Gua, studied by the Kelloggs, and the most recent was Viki, whose third birthday is described here by her "foster mother." Keith and Cathy Hayes have reported in the scientific journals their efforts to teach Viki to talk, but it is in the book by Cathy Hayes where we find a delightful combination of the sympathetic viewpoint of a "mother" with the detached objectivity of the scientist. In her book Mrs. Hayes describes their adoption of the three-day-old infant, their systematic efforts to teach her to speak, and numerous illuminating (and amusing) incidents in the development of this strange youngster. Chimpanzees are brighter than children, age by age, until the human child reaches the stage where language emerges. Notice how well Viki was able to respond to language commands as long as they were in reference to concrete actions and things. Her limitations in abstract language and the production of language severely restricts her intellectual growth.

Cathy Hayes is now on the editorial staff of the University of Chicago Press and has a real human (and talking!) child of her own to raise. "A day in the life of a 'three' " is Chapter 23 of her book, *The Ape in Our House*, published by Harper. Copyright, 1951, by Catherine Hayes. It is reprinted by permission of the publisher and the author.

August 28, 1950, was Viki's third birthday. A detailed account of that day may serve as a summary of the troubles and triumphs of Viki's daily life.

At 8:00 A.M. Keith unlatched her crib and raised the top. Out sprang Viki, like a large furry ball. She dashed to the bathroom and onto the diaper-changing board. Keith unpinned her and she leaped to her potty, just in time.

Next Keith gave Viki her toothbrush and she brushed her teeth, making little pleasure barks over the appetizing tooth powder. Finally, she washed her face. Most of it received only a swipe of the cloth, but she stood on the rim of the washbasin and peered into the mirror, to give her eyebrow ridges an exaggerated share of attention. Her toilet completed, she was put into her room until breakfast was ready.

At 8:30 A.M. I came downstairs. Viki greeted me with a soft "uh uh uh uh" through her screen door. She watched me getting breakfast with mounting interest, until, by the time I set the tray on the coffee table, she was hopping up and down and banging on her door.

I opened it and out she burst with a rush. She bounded to the top of the radio, ricocheted off the couch and onto the desk, where she stood hooting her hello to the new day.

I held out a glass of orange juice and she took it daintily between her thumb and forefinger. I poured the coffee and handed a cup to Keith. Viki put down her glass, which was now empty, climbed to the arm of Keith's chair, said "Cup!" and then helped herself. I gave her a cup of coffee of her own. Drinking all the while, she wandered about the room, over chair rungs, under tables, up and down door jambs. When her cup was empty, she asked me for a refill by holding the cup under the spout of the coffee pot and saying, "Mama!" and then, "Cup!"

She carried her second cup of coffee to the desk, where she lay on one elbow and blew at her coffee to cool it. I passed a plate of doughnuts. Viki took one in each hand and dunked them.

At 9:00 A.M. the phone rang. While Keith talked, Viki stood on the table, one hand on his shoulder, glancing first at him and then at the phone. As he finished his conversation and started to hang up, she claimed the receiver and put it to her ear. She listened for a minute with a faraway look in her eyes. Then she made a Bronx cheer and hung up.

Jumping lightly from the table, she picked up her red wooden box and put it over her head. Since it covers her whole face, this box makes good blindman's buff equipment. She ambled about the room, bumping into things and chuckling. Unfortunately, she bumped into her juice glass, and it fell to the floor with a crash.

She snatched the box from her head and clung to me, looking shamefaced. I put her into her room while I gathered up the broken glass, and in the confusion, Keith escaped to the quiet of the Laboratory.

At 9:15 A.M. Viki and I went to the garage to do the washing. She stood beside the tub, watching my every movement, and "helping" by dousing the clothes up and down, and rubbing them on the washboard. But when she lifted them high in the air to suck out the soapy water, I cried, "No! No!" She hooted at me and climbed up the wall. Straddling a rafter, she lay silently, staring at me.

When I started the rinsing process, she scrambled down. She is a real help here, since her strong hands can wring the laundry drier than mine are able to. However, when we had finished wringing, and I was ready to hang up the clothes, she wiped her sandy feet on them. "Oh, Viki, look what you've done!" I wailed, apparently sounding more distressed than I had intended, for she put her arms around me and kissed me thoroughly.

Then she ran off, and returned a second later with the spray gun. She took the cap off, held the sprayer under the faucet to fill it with water, screwed the cap back on, and sprayed the garage floor.

By 10:00 A.M. we were finished with the washing, and went inside to do our housework. To cheer us along, I turned on the radio. As I squatted before the dial, Viki jumped to the top of the cabinet, placed her hands on my head, and leapfrogged over me. When I started to get up, she pushed me down again, so that she could have one more leap. Then, as I walked away, she tuned out the station, and when I stooped down to adjust it, she took still another jump.

Viki helped me carry the trash to the garbage pit for burning, she pushed a dust mop around her own room, and when I started to wash her bed and its waterproof mattress, she took the cloth away from me, and climbed in to do the job right. Finally she performed her one regular chore: she washed the bathroom mirror and soap dish, rubbing so vigorously that the paper toweling disintegrated.

At 11:00 A.M. it was time for Viki to "go to school." As I took the equipment from the hall cabinet, she grinned and guided me to our work table with eager little barks.

First we worked on our six-piece jigsaw puzzle. Viki assembled it correctly without much trouble.

Next I put paper and crayons before her. She scribbled enthusiastically enough, but made no effort to copy my marks, although she had been imitating my housework all morning. She paid no attention either when I drew a border and told her to keep her scribble inside of the line. (I'm sure that she could do these things, if she knew what I wanted, but I cannot figure out how to get this idea across to her. It would be so simple with language! Her little friend Chrissie recently visited her older brother's school. There the children taunted her about being "too little to stay inside the line." Chrissie worked feverishly until she had mastered the idea.)

Next I gave Viki some tasks aimed at improving her dexterity. At "school" on her third birthday she built towers and bridges of tiny dice. She also threaded a needle, worked a spring paper clip, and scribbled with a pencil the size of a match in a miniature notebook.

12:00 noon was Viki's lunchtime. (She now eats breakfast and dinner with us, as a child would, but at lunch she is still working for food.) On her third birthday, we built matching towers. She imitated my selection of blocks without error. When instead of a tower I built a train of three dissimilar blocks, she selected three matching ones from the jumble before her and assembled them in the same order as mine. Finally I built a three-block tower without letting her see my construction work. When I showed it to her, she immediately selected the correct blocks, and stacked them to match my finished model.

At 12:15 P.M. we were ready to go out into the yard. (This play space now serves its purpose well, since Viki seems to have given up her ambition to break out of The Fence — at least temporarily.) Viki made a dash for her swing, which we have recently suspended from the only tree in the yard. She chinned herself on the elevated bar, and climbed the ropes; then she came to me, and taking me by the hand, led me to it. There she climbed to the bar and sat waiting to be pushed.

After I had pushed her for a while, she ran to a nearby lawn chair and climbed up on it. She waited expectantly, eight feet from the swing, until I fulfilled my part of this popular game by swinging the bar toward her. She leaped off into space, and with perfect timing grabbed the approaching bar and flew through the air on it.

Bored with the swing, Viki went to the sandbox. The first thing she did was to "plant" a weed. I was very impressed with the way she carefully pressed the sand around it until I remembered that she had recently seen Mrs. Clarke planting some young seedlings.

Now Viki began an entirely new activity. Bending over from the waist, she made an impression of her hand in the sand, and then deepened the print with her finger. She made a print of her foot, too, and while so doing she seemed to notice for the first time that her toes wiggle all as one while her fingers can move independently. She plunked down on the sand and studied this phenomenon. She found that she could grasp the toes and move one at a time, but on their own, they would act only as a team. But this seemed to be pretty deep stuff for a three-year-old chimpanzee; she jumped up from the sand all of a sudden, and raced madly around the yard.

She was interrupted by a car driving up to Mrs. Clarke's house. She sat on the edge of her sandbox, clapping her hands and calling to the people. They waved to her, but did not come over. She went back to the sand. Scooping up a handful, she stirred it into the rain water which had collected in her coaster. She then brought a handful of this mixture and lovingly patted it onto the top of my head. We hurried indoors.

While I cleaned the mud out of my hair, Viki washed her hands vigorously.

At 1:00 P.M. we returned to the yard to play with balloons. (Viki is very destructive of rubber balls. Therefore, in the interests of economy and habit formation, I am giving her several balloons every day. She plays with them as she does with balls, but when she bites a balloon, she loses her gay and lively companion in one bang. Perhaps in time she will thus be shown what we cannot tell her, and we can resume our various games with the more expensive balls.)

On her birthday, when Viki had broken the last of the balloons, she looked forlorn. Picking up the fragments of one, she put the mouthpiece to my lips. I showed her that it was no good, and tossed it away. It landed on the wires of The Fence. Viki approached it cautiously. Then she took my hand and led me to the place. She tried to make me touch the balloon, although she herself avoided The Fence.

At 1:30 P.M. I brought out the typewriter to bring Viki's diary up to date. She immediately planted herself between me and the machine. It was a very hot day, but I have grown used to her furry little self against me. I did not even mind when she bit hunks out of my carbon paper; but when she began snatching each type arm as it flew up, I chased her away. She hooted at me sassily and took it out on her sand bucket. Laying it on its side, she stomped it flat. Then, with a grin, she came back to me, to help some more with the typing.

By 2:30 P.M. I had finished the notes and lay back in a lawn chair to rest. Viki sat on the arm of my chair and we gazed out toward the highway together. Suddenly she startled and said, "Boo!"

Following her gaze, I saw that beyond the Grove, across the road, in the middle of the town's cemetery, a golden spot of sunshine was falling through a gap in the overcast sky. As we watched, the break in the cloud came toward us, leaving the cemetery clearing a black hole, while the trees between the clearing and the road were suddenly a shining curtain of Spanish moss. Next the road became a silver ribbon with the trees as a somber backdrop. Viki's "boo" became higher, almost shrill. The sunny spot came slowly toward us, and one by one the pecan trees were flecked with sunshine. Viki's arm gently circled my neck, and when a second later we were warmed by the dazzling sun, her "boo" had dropped to an awestruck murmur.

At 3:00 P.M. we took our bath. Viki submitted bravely to the soaping process, but her real pleasure came afterward, as she played in the water and rinsed herself with the spray.

At 3:30 P.M. we went to Viki's room to play. I proposed our old game "Go get the dog!" without noticing that the toy was not in sight. Nevertheless she went in search of it. For five busy minutes, she dug through her box of blocks, looked under the couch, and even under the rug. Finally, she emerged dusty and triumphant from behind her crib, holding up her toy dog.

After a session of this game, I tried to interest her in block construction. She ignored me until I incorporated some toy cars into my elevated highway structure. The she pushed the cars back and forth for about ten minutes.

At 4:00 P.M. I told Viki that she must play by herself now, while I prepared the birthday cake and the dinner. As I closed her screen door, she galloped off to her mirror, where she sat examining her teeth and making play sounds like "ahhh," "tsk," and "kkkkkk."

Next I heard her pounding at her toy workbench, where she has mastered the hammer and nail, the claw hammer, the screw driver, and the nut and bolt. (The other toys available to her at all times in her room include a tricycle, stuffed animals, a toy telephone, blocks, and various educational toys. Only these are rugged enough to withstand her vigorous play. Things like clay, painting and sewing equipment, jigsaw puzzles, and the plastic animals of her toy farm are given to her only when we can observe and supervise her play.)

At 4:15 P.M. I went to her room again, to let her come and beat the cake batter, one of her favorite chores. But I found her asleep on top of her crib, lying on her stomach, with the dog clutched in her arms. (Short naps before or after dinner are her only daytime sleeping.)

I glanced about her room and noticed an odd structure in one corner. She had built a tall arch with two blocks on each side and a fifth block across the top. Later, we saw her making sounds into her toy phone and then holding it toward this structure. Keith hypothesized that she was hanging up the phone. I thought it might be her "baby" whom she was letting "listen." But she never told us what it really was.

At 5:00 P.M. I heard a commotion in Viki's room. She was pounding at the windows, and hooting. Papa was home!

I let her out and she jumped up and down as he opened the door. Then, in a wink, she was onto his shoulders and ready for a piggyback ride.

When I called them to the table, Viki slipped into her chair. She drank some milk, ate a forkful of asparagus, bit the buttered top off her roll, and then ran off, munching on a frankfurter. She ran to her room, where she got her dog, placed it upon her shoulders, and paraded past us — giving it a piggyback ride.

When Keith and I pushed back our chairs to leave the table, Viki leaped to her place and polished off her plate quickly.

6:00 P.M. Enter the birthday cake! Viki went wild at the sight of it, jumping around the room and sputtering food barks. (To her this was probably just another cake — as this whole day had lacked special significance. On the other hand, Chrissie had anticipated her recent third birthday for weeks. Chrissie can also give a rather explicit account of what the birthday celebrates. Viki may never know about birth until she herself witnesses it or experiences it.)

By 6:30 P.M. Viki was full of cake. She gently returned her empty plate to the coffee table and went to the telephone. She held the receiver to her ear for a while, and then frantically dialed several numbers. (Her dialing is completely random, but occasionally she does call an actual number.) Suddenly, now, she stopped dialing and said "Boo!" At the same time we heard a faraway voice calling, "Hello! Hello!" I murmured apologies and hung up.

By 7:00 P.M. I had cleared away the dishes and was ready for the evening's entertainment. I gathered up a supply of clean diapers and Viki's blanket. Viki began making pleasure barks of anticipation. And when Keith asked, "Viki, do you want to go to the show?" she raced to the door, all gay and ready to go. In the car, she bounded from the front seat, to the back seat, to the place behind the wheel, which she energetically turned back and forth.

At the drive-in theater, she made excited little yelps as her beloved public peeked in the windows and laughed at her antics. The little boy in the next car saw her sitting a-straddle my open window and insisted that he be allowed to sit in the window of his car. His father complied with small enthusiasm.

First came the color cartoon, always fascinating, and then a newsreel, which featured a gymnastic contest. Viki commented freely on the performance of the athletes who did many of her best tricks.

When the main feature started, she turned her attention to the adjacent cars. To our right were two middle-aged ladies who stared at her silently. She found the car on the left more rewarding. This carful of children and grownups whispered "Psst!" to get her attention. She obliged by blowing spit bubbles at them.

At 8:00 P.M. the screen resounded with a duel, complete with clashing swords. Viki attended carefully to this part. When the hero raised a glass of wine, to toast his fallen foe, Viki said, "Cup!" I decided that it was time for refreshments.

At the refreshment stand, a little girl, about Viki's age, told me a very unlikely story: "I saw a little furry baby," she said. "Back there, the man had a furry baby in a pink dress."

Her mother looked embarrassed and said, "As we passed one of the cars, she saw a monkey inside and she was simply fascinated. Calls it a 'furry baby.' I can't imagine why she singled you out to tell this tale to. I'm sorry."

"Guess I look like the gullible type," I said.

Returning to the car, I found Keith in a stew.

"Will you please hold her a minute? I'm trying to light a cigarette and she keeps blowing out my lighter."

Viki drank her soda pop, helping herself to handfuls of popcorn from our family box. Then she went to the back seat and became very quiet.

At 8:30 P.M. I glanced back, expecting to see her asleep. Instead, she was at the window, making faces. Her audience was five little children who sat crosslegged on the ground, silent as Indians as they looked at her.

Now Viki climbed into my lap and put my hand on her ribs. I tickled her. She chuckled. I stopped, and she put my hand back on her ribs, pushing it suggestively until I tickled some more. Then, all of a sudden, she was asleep.

At 9:30 P.M. we prepared to leave. The intermission lights had gone on, causing Viki to jump up and look about. Now, for the first time, the two ladies in the car to our right spoke, "She's very beautiful, isn't she?"

I agreed that by chimpanzee standards, she is indeed a fine specimen. "But her eyes!" one of the women said, "Those eyes would be beautiful in any species."

It was 10:30 P.M. when we arrived home, and Viki was too sleepy to wait for her bedtime cocoa. She curled up on the couch and closed her eyes. When I asked, "Don't you want to say goodnight to Papa?" she flipped her hand a few times and let it fall to her side. I picked her up then, and took her to her crib.

Viki's third birthday was a very ordinary day in her life, and her activities were quite typical of this period. We have seen that, except for language, she is still quite similar in abilities to the child of this age. We realize, however, that her interests are a little different, more athletic, less verbal.

We have seen also that the advantage of language is much more than a mere chattering of words. Even at this early age of three years, the child, through language, is gaining more information, inspiration, and direction from adults than we could hope to give Viki.

We may consider intelligence as made up of three components:

1. The individual is born with a certain amount of *innate capacity*, and our experiment establishes this one fact at least: Until three years of age, the only obvious and important deficit in the ape's innate intelligence, as compared with man's, is a missing facility for using and understanding language.

2. The *personal experience* component of intelligence is what the individual learns for himself, motor and manipulatory skills, basic perceptions, social interplay, the elementary stunts of getting along in our civilized jungle. Viki has done very well in this respect. Exposed to the life of a child, she has absorbed about as much, through personal experience alone, as a child could.

3. But there is a third element of intelligence — *group intelligence*. Through language, the individual at a very early age begins to acquire knowledge secondhand from teachers, books, and daily communication with other people, infinitely more knowledge than he could ever gain through personal experience. Language conveys not only information, but ideals, traditions, and abstract philosophy. It fosters that cumulative thing — invention. It enables the mechanic and the mathematician to make use of each other's skills. And this has been going on for thousands of years in man.

This aspect of our intellectual life is so characteristic of our species that we take it very much for granted, and seldom appreciate how mentally ineffective each of us would be if we had to function strictly as individuals. Much has been made of the human brain's ability to cope with any change in our environment. But no one man, isolated from birth, could do this very well. It is man's collective brain, working over the centuries, which has made us increasingly versatile. It is man's unique ability to communicate knowledge which has led to that peculiarly human product, civilization.

Since apes do not acquire language to any significant extent — not even privileged apes like Viki, who are coached intensively on it, and who could profit a great deal by it — it seems unlikely that apes ever have or ever will develop a civilization.

Our Viki has tapped our cultural store of knowledge to an impressive degree, but the child of three has greater access to it. Year by year, Viki will continue to learn as much as we can communicate to her, but without language, communication will be difficult.

Upon man's innate capacity for using language depends not only the growth of civilization, but perhaps its very survival. For instance, if my lamp were to go out at this moment, I would first of all replace the bulb. If my lamp remained dark, but the other lamps in the room were on, I would examine the switch or the socket. If I saw any irregularities, I would repair them — after consulting a more informed human or a book, in all probability, for while I am very ignorant personally, almost every accomplishment of the human race is available to me in the world's massive accumulation of literature.

If all the lights in the room went out, I would replace a fuse, and if this did not remedy the matter, I would assume the trouble to be a power failure. The idea of trouble-shooting in a power plant appalls me, but if it suddenly became my responsibility, I'm sure I could find some books which would tell me what to do.

Now what would happen if the world were to be populated only by apes, each as educated as Viki is likely to be by adulthood? What would Viki do if her lamp went out? Being a bulb-snatcher of long standing, she might (accidentally or with some insight) remove a defective bulb and replace it with a sound one. This is as far as her training now goes. We could show her how to replace a fuse, by imitation, or how to repair a plug, or a socket, or a switch. We might even set up an elaborate training program, showing her how to test all these trouble spots in a logical order. But there is not time enough to teach her, in this way, even a small portion of what the child is simply *told*.

And some things cannot be communicated by any amount of demonstration or personal experience. If the trouble with Viki's light lay in the power plant, there would be no hope of her resolving it. How could she be given the idea of electricity, of its being generated, and coming from a distant place? Left in the hands of the most supereducated apes imaginable, our civilization would fall to pieces. One by one, the lights of the world would go out.

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Some Implications of the Study of Animal Behavior

W. H. THORPE

Some of the most significant work in comparative behavior has been conducted in England and Europe in recent times, and much of it has been done by biologists. The theme of this article, written by a British zoologist, is that the behavior of animals is in many instances remarkably similar to that of man. It is much more adaptive and environmentally determined than the old idea of stereotyped instincts would indicate. The author describes numerous remarkable investigations which show that animals far down the phyletic scale are capable of perceiving stimulus relationships and reacting to them appropriately for maximal survival. Social stimulation is capable of noticeably modifying supposedly innate patterns of behavior, such as the songs of birds. In stressing the essential continuity of behavior, Thorpe tackles the knotty question, "Is there purposefulness in the behavior of animals below man?"

Dr. Thorpe is a Fellow of Jesus College, Cambridge, and has held posts in the United States at the University of California, Harvard, and Yale. His research on animal behavior has taken him over much of the world. The article below is based upon his presidential address to the Zoology Section of the British Association for the Advancement of Science. It is reprinted from the June, 1957, issue of *Scientific Monthly* (pp. 309–320) by permission of the publisher and the author.

The modern school of animal behavior studies can, with some truth, be said to have begun with Darwin, for the publication — in 1872 — of *The Expression of the Emotions in Man and Animals* was an important landmark and ultimately had a big influence. But its immediate effects were small, as were those of Spalding's admirable experiments on instinctive behavior in young chicks, published the same year; and the subject remained largely in the anecdotal phase until the later years of the century. Then the rise of the associationist or connectionist psychology in America, based on Thorndike's experiments with the "trial-and-error" escape of cats from his puzzle-boxes, and the development in Russia of the study of the conditioned reflex, led to a purely mechanistic-physiological view of animal behavior which found expression in the "behaviorism" of Watson and Loeb. Behaviorism had its merits and was in some degree a healthy reaction from the uncritical anecdotalism of earlier writers. But it was woefully inadequate as a general theory of animal behavior, and its life, in its original rather crude form, was short. In its turn it gave rise to revulsion on the part of those who were studying the more complex aspects of behavior, such as visual perception, where the inadequacies of behaviorism and simple associationist ideas were startlingly apparent. So it was that a group of German psychologists and sensory physiologists — Wertheimer, Köhler, and Koffka — gave the pendulum a swing in the other direction with the development of the Gestalt psychology.

What was happening in England while the pendulum was thus oscillating in other parts of the world? The story of English work in animal behavior is, I think, very characteristic of the English mentality. There was a cautious, conservative unwillingness to be rushed from one extreme to another, which can be found in so many branches of English life and thought. Spalding had unfortunately died young, and the characteristically English students of animal behavior succeeding him were Lloyd Morgan and Hobhouse. These two had indeed reacted from the uncritical credulity of Romanes but not with any extreme swing in the other direction; and I think it is instructive to look at the animal through their spectacles. Both Lloyd Morgan and Hobhouse were primarily philosophers, and their deservedly great reputation rests principally on their philosophical work. But they were both men of great general learning, having a sympathetic understanding of animals, combined with a genuine interest in experiment. While giving full weight to field observation and anecdote, where reliable, they both saw that the urgent problems could be solved only by experimental investigation. I intend to take Lloyd Morgan as the representative of the two and compare his attitude to animal nature with our own, more than half a century later.

PIONEER IN BEHAVIOR STUDY

Lloyd Morgan was the real founder of experimental animal psychology. His attitude to animal nature can best be made clear by considering his belief in the three levels of mind (assuming that the instinctive was a level of mind and not only a level of body behavior). These three levels he called percipient, perceptive, and reflective, and he regarded them as associated, respectively, with the subconscious, conscious, and self-conscious mind. Percipience he regarded as the equivalent of sense awareness; animals having nothing more than sense awareness would be percipient, as babies at birth or perhaps only before birth. He says: "Bottom-level minds, if such there be, are percipient only, having sense awareness and no more. Middle-level minds are perceptive and percipient, while top-level minds are reflective, perceptive and percipient." Thus, in contrast to C. Sherrington (*1*), who spoke of instinct as implying some slight degree of anticipation, Lloyd Morgan regards the subconscious mind of instinct as mind at the percipient level of mental development, having no sense of past or future. Conscious mind is perceptive, and this betokens expectation based *on what has been learned on prior occasions.* The reflective mind is regarded as self-conscious in the sense of embracing, to some degree at least, both past and future in relation to an awareness of self. So he would see in "trial-and-error" (an expression which, incidentally, we owe to him) nothing more than unreflective "fore-experience" or simple expectation of the future without a fore-plan for it; whereas trial-and-error when it becomes reflective leads to a plan for the future also. This "plan" is what W. Köhler calls *insight.* The "plan" may be too elementary or too incomplete to cope with a given situation, in which case the only course open to the animal is to continue with trial-and-error, at any rate for the time being. But if the external situation is very simple, or if the plan becomes sufficiently articulate and complex, then it may give rise to the phenomenon known as latent learning or insight learning, and so the plan becomes open to experimental investigation. Lloyd Morgan believed emphatically that the study of animal behavior can give the investigator real knowledge of the nature of mental processes in animals, and that these mental processes play their part in controlling behavior. These mental events he regarded as something different from physical events. In this he was a psychologist of the old school, making quite clear his disagreement with any type of theory which looked upon animal behavior as explicable in terms of physiological mechanism and nothing more. Yet it is instructive to remember that Lloyd Morgan (2), far from beating swords into plowshares, successfully beat Occam's razor into a canon and thereby provided the behaviorists with their chief weapon. That Lloyd Morgan used it himself with great effect combined with circumspection hardly needs saying. Whether the behaviorists used it justifiably or wisely is another matter; it has certainly been of enormous value to comparative behavior studies in general and indeed in many other fields of science also.

This question of the relation between mechanism and mental events is one which has again come strongly to the fore as a result of the development of electronic machines, which are not only conditionable but which can even display behavior superficially characteristic of latent learning and of insight learning; and, of course, the postulation and investigation of mechanism is an essential method of approach for biologists. But this does not mean that the mechanistic hypothesis is conceivable as a fundamental explanatory principle in a biological philosophy, and it was this that Lloyd Morgan was seeking. As J. H. Woodger (3) has pointed out, we may talk of purposes in animals as in human beings, and we may, and nearly all of us do, think that something like purpose — at any rate in some animals — is the cause of at least the "higher" types of learning. But it is extremely difficult, at the levels with which we usually deal, as biologists, to prove the causal effectiveness of purpose in the sense that all other possible explanations are excluded. It is always possible to defend microscopic mechanism in principle, if you wish to do so, by making your mechanism complicated enough and by postulating enough submechanisms to meet all contingencies. This game of making hypothetical submechanisms can be carried on a long way and is at first sight very convincing, although there is ultimately a limit to it, for if we go on making our supposed mechanisms smaller and smaller, we come eventually to the subatomic level at which the concepts of form and even the idea of occupation of space lose all meaning, and the idea of physical causation has likewise disappeared. This, however, is fortunately far beyond the level with which biologists have, as yet, to concern themselves; and the level of micromechanisms which biologists are tempted to regard as plausible can often be neither refuted nor verified. But, as W. E. Agar says (4), anyone who accepts this kind of explanation as by hypothesis responsible for the whole of animal behavior, must also, of course, accept it for his own consciously purposed acts; unless he holds dogmatically that there are factors in human behavior which are different not only in degree but in kind from the factors determining the acts of lower organisms. Nevertheless, as biologists we are entitled to claim that when we speak of animal behavior as appearing, shall we say, expectant or anticipatory, we are, for the time being, speaking of a mechanism which acts as if it were expectant or anticipatory, and reserving judgment on more fundamental issues. Biologists may be justified in this attitude only as long as they realize that this is a linguistic device and not a philosophical position. Thus Lloyd Morgan, by avoiding the extreme views of both those camps which were warring on the other side of the Channel and across the Atlantic, achieved a general attitude toward animal behavior and experiment thereon which is striking for its sanity and balance. Study of it can yield much profit today.

But let us return to consideration of the position on the Continent. The coming of the school of behavior study to which the name *Ethology* was first applied in 1935 was an expression of the reaction of zoologists against two extreme camps: those of the old anecdotal comparative psychology, on the one hand, and the rigid Russian reflexology, on the other. The old subjective animal psychology was in danger of having us suppose, for instance, that a bird building its nest for the first time foresees the young it will be feeding some weeks later; that the salmon returning to the river of its birth is looking forward to the spawning period. So it was a natural and, indeed, an inevitable step for naturalists to get back once again to the descriptive, empirical, objective phase and to recommence by observing, recording, and analyzing the animal's behavior experimentally — first in as natural a situation as possible and then with simple experimental controls. And here we see how Darwin was in fact a forerunner of modern ethology, for in his

The Expression of the Emotions in Man and Animals he is concerned not so much with the emotions as they are supposed to be felt by the animal (though this is implied) as with the similarities of emotional expression and behavior in widely separated groups of animals.

NEW APPROACH TO ANIMAL BEHAVIOR

What, then, was new in the approach to animal behavior started, and to a large extent characterized, by the early papers of Konrad Lorenz? First as to technique: as complete an inventory as possible must be made of the whole system of actions of the animal in its normal environment; and such special techniques as have been developed are primarily those which aid and make more precise this primary observation — the technique of keeping animals under observation yet with the minimum of interference; the technique of marking individuals so that they can be recognized throughout large stretches of their lives; and the techniques which aid in the recording of their consequent actions and behavior. Ethology is thus essentially a naturalist's approach, and it first emphasized and brought under experimental study stereotyped, relatively rigid species-characteristic actions (for example, the web-spinning of spiders, the nest-building of solitary and social wasps). Second, it drew attention to the evidence that such actions are governed in some degree by an internal drive, a point which most zoologists who failed to remain field naturalists (that is, most zoologists!) seem almost completely to have forgotten. Third, it produced a hypothesis to account for this internal drive which allowed scope for the action of hormones and elaborated it into a hierarchical scheme of organization.

This internal drive is of the very essence of the meaning of the word *instinct*. Most of the workers who had seriously considered the subject prior to 1935 uttered vague generalities about "tension," "nervous energy," and so forth, which were of little use either as explanatory concepts or as guides for future research. Lorenz (5), in papers which appeared between 1935 and 1939, and Karl Lashley (6), in a paper dated 1938, realized independently that the more promising way of tackling this problem of the internal drive behind instinctive behavior would be to study not actually the drive itself but rather the internal system of coordination of special behavior patterns, on the one hand, and the special sensory mechanisms, on the other. They saw in fact that the complex and stereotyped action-system and its coordinating mechanisms might be more fundamental to the subject than the question of drive, and they suggested that a study of these mechanisms might eventually throw further light on the problems of drive and motivation. Such an approach was not new, for human psychologists [notably R. S. Woodworth (7)] had pointed out that habit mechanisms, at any rate in human beings, may become drives and had implied that habit and instinct had therefore much in common, and that in both cases the coordinating mechanism of the behavior pattern might itself be producing the drive. One has only to extend this concept from the learned behavior, which in human beings we call habits, to the inborn, instinctive actions of animals to arrive at the first essential idea of the Lorenz-Lashley scheme. Looked at physiologically in this way, drives are seen to be nothing more than expressions of the activity of specific mechanisms, and the general theory which Lorenz built on this quickly provided a more comprehensive framework for the description and further study of instinctive behavior than any which had preceded it.

The new approach resolved many of the earlier difficulties. It emphasized that there are some elements of what we call instinctive behavior which are extremely rigid and indeed, in their way, as constant as anatomical structures and therefore potentially just as valuable for the study of evolutionary relationships. It was also pointed out by Lorenz that where, as is so often the case, such very rigid action-patterns constitute an end-point or climax of either a major or a minor chain of instinctive behavior, they are in some sense consummatory in that they effect the release of the tension which has, up to that point, been activating the instinct in question. Such *consummatory acts* are familiar to all. One need only mention the elaborate nesting and egg-laying behavior of the solitary wasps, the stereotyped sexual displays of birds, or the elaborate and apparently inborn movements of innumerable predatory animals, whether fish, birds, or invertebrates, by which a particular kind of prey is successfully caught. This view, then, involves the idea of the coordination mechanism of the fixed consummatory act, giving rise to the tension which activates the instinct, until it finds relief in discharge of the act in the appropriate situation. As long as the act remains undischarged, the animals continue to show an introductory phase comprising more or less complex searching activities, the appetitive behavior. This behavior is such that there is a reasonably good chance of its bringing the animal, before long, into the appropriate situation for the consummatory act to be performed. The animal is *apparently* looking for its prey, *apparently* searching for a nest site or nesting materials, or else is going through a series of actions, such as those employed in nest-making in insects and birds, which will in due course lead on to the completion of the particular chain of instinctive behavior. This distinction into appetitive behavior and consummatory act was not in itself new. Sherrington and others had used much the same terms in much the same sense; but it was important just at this juncture because it resolved the apparent disagreement of previous workers as to the relative flexibility and rigidity of instinct. For by definition the consummatory act now became the characteristically fixed part of the behavior — the fixed-action-pattern, as it is now called — and the preliminary or searching behavior was regarded as the flexible part, where learning ability and, perhaps, "intelligence" were able to show themselves. Another immediate advantage of this scheme lay in its apparent avoidance of the vitalistic approach, for the objective of the animals is now no longer seen as the attainment of the final biological goal or result (which it is, of course, inconceivable, in most cases, that it could foresee), but rather the performance of the consummatory act itself, which can be achieved only as a result of finding the appropriate environmental pattern of stimulation, the *releaser*, which can "unlock" the *innate releasive mechanism* and so allow the act to proceed. The new theory substituted a physiologically reasonable system for a largely untenable vitalistic one, and this was another reason why it has ever since yielded such good dividends in promoting research.

While the idea of a relatively rigid consummatory act is thus a theoretically sound one, and while the separation into two categories probably continues to be as useful now as it has ever been, recent researches — particularly those of the last decade or so — have made it abundantly clear that the distinction is not hard and fast. For instance, much appetitive behavior contains rigid consummatory acts, of what might be termed a minor grade, and many examples are now known in which appetitive behavior and consummatory act vary greatly in degree of rigidity and flexibility. Both may show some evidence of internal activation; both may be stereotyped to some degree and show some rigidity, and both may be to some extent flexible. I shall return to this subject shortly and give some examples to illustrate the point; suffice it to say now that the characteristic instances of flexible appetitive behavior and rigid consummatory act can be regarded as the two ends of a series.

So to some extent the original picture drawn by Lorenz, which was so attractive in its clarity and simplicity, has, as always seems to happen in scientific research, been complicated and somewhat blurred by the detail since added to the picture. And this in its turn has important implications for our ideas of animal nature. If the internal organization of the consummatory act is not now seen to be as rigid and stereotyped as was formerly thought, it becomes harder to envisage it as providing the specific internal motivation for behavior which Lorenz supposed. Besides "seeking" to discharge its fixed-action-patterns and so relieve the instinctive "tension" accumulating around the mechanism, there is now evidence that some of the searching is an attempt to find a key environmental situation. Perhaps there is also some real, though very limited, element of purposiveness in the search for a satisfying situation. Actions are not always brought to cessation by exhaustion of internal drives or by the cessation of the eliciting stimulus. On the contrary, there are external situations which, instead of, or in addition to, acting as releasers for the next phase of behavior, serve to bring the previous phase to a close. In this case they must be effective in stopping a piece of behavior even when the original eliciting stimulus is still present. They are thus *consummatory stimuli* or consummatory situations, or, in simple English, *goals*. Thus we now see that the goal is not always the performance of an action; it may sometimes be the perception of an environmental situation. The attainment of such a situation may in fact be as effective in bringing a particular piece of behavior to a close as is the satisfaction of a physiological need or exhaustion of the internal drive behind the fixed-action-pattern or consummatory act.

INTERACTION OF LEARNING AND INSTINCT

The original instinct theory of Lorenz thus gave a picture of the animal as "searching," by means of a series of stereotyped orientation mechanisms, for the situations which would release the consummatory acts. The recognition of these situations was largely inborn, though of course it could be modified to a greater or lesser extent by reflex conditioning or other forms of learning, and the act itself was the true goal of the behavior. When the act is at last performed or, as we would now add, the consummatory situation at last reached, that particular behavior chain is for the time being completed, and so the episode is brought to a close. It may be a final conclusion, as in such behavior as the cocoon-spinning of Lepidoptera, where, once the highly elaborate series of acts has been accomplished, a part of the life cycle has been achieved once and for all and will never be repeated by the individual; or, on the other hand, it may be a type of behavior which is repeated constantly during the whole life — as feeding or mating, for instance — and the whole system may be due for reactivation in a period of minutes, hours, or days by hormonal control internally aroused or by other internal complexes of stimulation. We know that, valuable as is this picture, the account it gives is not complete.

These newer theories of animal behavior have also done valuable service in emphasizing the significance of the interaction of learning and instinct in animals. I said just now that learning abilities play their part particularly in the flexible appetitive behavior. Very many higher animals can learn to adapt their hunting methods, at least in some degree, to the particular circumstances which they encounter and to the particular methods of avoiding action employed by the prey which they find. In contrast it may be very difficult or impossible for an animal to adapt its cocoon-building or mating behavior even after repeated lack of success. But if the two categories of appetitive behavior and consummatory act are not as sharply defined as we thought, then we must be prepared to find (as indeed we do find) that some appetitive behavior is more rigid than we should have originally expected and some consummatory acts more flexible. And this conclusion has brought into prominence the importance of the type of learning known as imprinting — not really a new category of learning, but merely learning ability restricted to a particular and perhaps very short period of the animal's life and orientated by innate predisposition to a particular circumstance or in a particular direction; as when an insect or an intertidal mollusk learns a particular diurnal rhythm of behavior from its first day's experience of it, or when a young bird learns the characteristic appearance of the species by following its own parent or learns the niceties of its specific song by imitating its neighbors during its first few days of singing in a territory. This kind of learning is important when we are thinking of the implications of modern behavior studies for our views on animal nature. Finally, it has been shown that highly elaborate learning processes may be displayed by some animals possessing nervous centers far inferior in mass and complexity of structure to the mammalian cortex. Not so long ago, for instance, insight and insight learning were assumed to be the prerogative of the highest mammals only, and it was thought that only nervous structures of the complexity, mass, and elaboration of the mammalian cortex could possibly provide the mechanisms necessary for the production of such apparently intelligent responses. Now we find that behavior giving good evidence of insight is found not merely in mammals but also in birds, fish, some arthropods, and perhaps in organisms even lower in the zoological scale. In fact our present knowledge of complexities of perceptual organization in the homing bird and the foraging honeybee have made it clear that in certain limited respects some of these creatures rival all but the highest mammals, if indeed they are inferior even to them. So it follows that our ideas about the mechanism of brain action may need a drastic revision as a result of some of the recent studies of submammalian and invertebrate behavior.

"INSIGHT" IN THE HIVE

Let us now consider actual examples of recent research bearing upon some of these crucial questions of the goal of the animal, the perception of complex releasers, and the level of integration achieved. First, let it be said that it is quite difficult to find an example of a metazoan animal whose sense organs and responses are such that one is convinced that it is, to use Lloyd Morgan's phrase, percipient only — that is, responding to crude sense-data and not in fact displaying some more or less elaborate organization of perceptual relations similar to what we usually regard as insight. Until a few years ago the division of labor among workers of the honey bee was thought to be based upon the physiological states of the insects concerned, and not to be directly correlated with the needs of the colony as a whole. Thus it was thought that the newly emerged worker was compelled, by physiological conditions arising from the age and state of its organs of internal secretion and its nutrition, to go through the series of actions appropriate to the cleaning out and preparation of cells in the hive, whether this particular work was required by the hive at that time or not. If it was unable to find a place for this particular activity, then it was forced to remain idle until the development of its glandular mechanisms rendered it capable of the next series of activities, which might, for instance, be comb-building. So it was thought that each individual went through an inevitable and ordered series of actions, such that by the time the first half of its life was completed it would have done its share of all the duties which had to be done inside the hive, its final occupation (marking the end of its life as an indoor bee) being that of acting as a guard bee at the entrance. After that, it becomes an outdoor bee, and a similar and further series of actions appropriate to the outdoor life, such as foraging, are then gone through, physiologically conditioned as before. While it may be that the *average* worker bee may spend the greater part of its time in some such sequence of actions, it is now clear, from the work of M. Lindauer (8), that the program of work carried out by the individual is not, in fact, primarily or exclusively determined by the physiological state of the insect but is dictated by the needs of the colony as a whole. Moreover, it seems clear that regulation by the colony's needs must be through an elaborate series of releasers — mostly proprioceptive, though no doubt chemical releasers are also very important. Thus the individual cell-building worker seldom or never itself carries out in complete, correct, and uninterrupted sequence the whole process of cell construction. Yet it performs every action of this sequence innumerable times, as and where required. It may, for instance, start a cell with the wax produced from its own glands, which it has manipulated. It may then put the finishing touches to another cell, using wax supplied by another bee, or perhaps a bit of light capping taken and molded from a cell temporarily out of use. Then again — sometimes using wax from another worker, sometimes its own — it will perform the laborious and delicate tasks of planing and polishing to produce the thin cell walls — all this in the intervals of performing duties of entirely different kinds, such as feeding larvae, storing nectar, or attending the queen. Much of the time it may not be nearly as active as the legend of the "busy bee" might lead us to expect. In fact it may apparently waste a great deal of energy just wandering about the hive investigating this or that in an apparently random and useless manner, but perhaps all the while accumulating "knowledge" of the situation in various parts of the hive and of the places where jobs of various kinds may now or later be available for the doing (9). But whatever be the ultimate explanation of this new aspect of the behavior, we seem quite safe in concluding that the achievement of consummatory acts in the original Lorenzian sense cannot possibly be the sole mechanism whereby the instinctive behavior of the worker honeybee is taken step by step along its appropriate course. At least as important, and perhaps far more important, is the perception (and organization of perception) of the situation within the hive — perceptions which obviously are themselves goals quite as much as are any of the stereotyped actions which have been described. So here again we must speak of consummatory situations or consummatory stimuli, just as much as of consummatory acts.

NEST-BUILDING AND PERCEPTIVENESS

The same is probably true in lesser or equal degree of many behavior chains which involve the construction of elaborate nests. When such a bird as the longtailed tit finishes its wonderfully elaborate domed nest, properly lichened, lined, and with a perfectly constructed entrance, a great variety of different stereotyped acts must have been employed, and probably a still greater variety of consummatory stimuli perceived. In this particular case at least 14 different acts or combinations of acts have been involved, but even with all these the bird would, it seems, fail to produce a complete and perfect nest unless it had some "conception" of what the structure should look like and some "conception" that the addition of moss or a piece of lichen here and there will be a step toward the ideal pattern, and that other pieces here and there would detract from it. The bird does not in fact go on building up the top of the nest indefinitely; it does not build downward over adjacent twigs or cover them with lichen; it does not close up the entrance hole from outside — in other words, its actions are directional. It recognizes when to stop and shows evidence of having some very short-term purposiveness (not, of course, that it can possibly know, at the time of first building, what the ultimate objective of its actions must be), but purposiveness to the extent of being able to take the next minute step toward the completion of a dimly "seen" pattern of nest structure.

It is very difficult to distinguish in animals between directiveness, which is the property of all well-designed machines, and true purposiveness in the sense in which we use the word when referring to our own purposive behavior. But it does seem to me that at present the only reasonable working hypothesis is that an extremely short-term purposiveness, a foresight of one or two tiny moves ahead, is being shown by some animals in this kind of situation (*10*), and this is an important conclusion for Lloyd Morgan's position, since, as we have seen, he postulated that mental activity, at least on the first occasion in the life cycle on which a sequence of instinctive actions is performed, is percipient only. If we are right, now, it contains, as Sherrington also concluded, something more — a germ of perceptiveness.

COMMUNICATION IN BEES

The elaborate organization of sense perceptions and the nice interlacement of learned and instinctive behavior must be evident to anyone who thinks about the now widely familiar work of von Frisch on the transmission of information about the direction and distance of a food source from a foraging worker bee to another worker in the hive. We now know, for instance, that the performance of a figure-of-eight dance must be dependent upon an inborn behavior pattern of extraordinary complexity, since it is hardly conceivable that the individual worker bee can have the opportunity to learn the relation between the general idea "position of food source" and the orientation of the dance on the surface of the comb within the dark hive — another beautiful example of the coordination of inborn and learned behavior, producing in this case a language of remarkable economy and efficiency for the purpose in hand. Some interpretation of the dance must also be inborn, but it appears that young bees are unable to forage successfully until they have first gone through a learning process and reached a certain degree of perfection of dance-following within the hive. It appears that very few young bees leave the hive on independent excursions, but nearly all get their first detailed foraging experience as a result of, themselves, following a dance; for although the pattern of actions of the figure-of-eight dance and its correct interpretation are both inborn, following the dance needs special practice. Inexperienced bees often find difficulty in turning sufficiently rapidly and so may appear clumsy and confused at the sharp turns of the leader. Also, since their efforts are still somewhat spasmodic, they are rather easily interrupted by the other workers crowding round, and so may have to wait until they have the luck to follow a dancer in a region of the hive where there is not too great a crowd.

Still more astonishing, perhaps, are the recent developments in our knowledge — again due primarily to Lindauer (*11*) — of the methods by which scout bees choose new sites for the swarm to go to. Communication is in this case also effected by dancing, which now takes place on the surface of the swarm rather than on the comb. Since the new sites sought for are always some distance away, the dance is always of the figure-of-eight type, never the round dance, which refers only to near objectives. When the time comes for swarming (that is, when the hive is overcrowded with provisions and sealed brood so that the foragers can no longer process nectar), the workers are forced to abandon their normal activities. Most of them remain unemployed in the hive, but some of those who are particularly experienced become scout bees and fly out to look for a new home. These scout bees are apparently able to make an absolute estimate of the "quality" of the sites they discover (presumably a synthesis of the properties of shelter, accessibility, ventilation, and so forth) and they communicate this information about suitability by the vivacity of their dancing. Those that dance with greater vivacity are more likely to secure an "audience," and so there will be a tendency to concentrate interest from the beginning on those dancers which are communicating information about the best dwelling places. Scout bees which may, at first, advocate inferior dwelling sites may "change their minds" if their colleagues have better homes to offer, and so, after a longer or shorter period, virtual unanimity is secured, whereupon the swarm departs to its new home. Thus, the dances of the scout bees on the surface of the swarm indicate distance, direction, and suitability of site. This estimate of suitability must, in some obscure way, be an absolute one, since it has to be appreciated in competition with the similar estimate of other sites made by the other scout bees. How this complex estimation of a quality of a site can be standardized and expressed consistently as duration of "bouts of dancing" is at present exceedingly difficult to understand.

BIRD NAVIGATION

The sun-orientation mechanism of birds is now well-known from G. V. T. Matthews' recent book (*12*). In its correlation between inborn faculties and experience it is remarkably similar to that of the honey bee. In both there is appreciation of the position and movement of the sun, presumably inborn, together with an accurate internal clock. In both there is the innate ability to relate a given direction to the space-time standards innately provided and, moreover, to relate the observation of these standards to the knowledge of general topography and special landmarks gained from individual experience — although bees seem unable to do the reverse and relate a route flown under overcast skies, entirely by landmarks, with a particular direction. In both bird and bee there is also an appreciation of the relations between the position of a light source and the direction of movement (foraging flight, migration flight, homing flight), but the honey bee does even better than the bird in two respects. First, it must transpose between sun-direction and gravity-direction, and, second, it must be able to transmit information by transposition between the direction of the foraging flight and the straight run of the dance. As far as we know, birds do not need to transmit such information and so lack these additional faculties which the honey bee possesses.

These and similar studies of orientation and perceptual organization constitute some of the most startling recent developments of ethology. Naturalists of 50 years and more ago were deeply impressed by the complexity of the action-patterns of instincts. But they had hardly realized that innate *perceptual* organization must be no less complex, and the sensitivity and fineness of adjustment characteristic of many organs of special sense, as now revealed by sensory physiologists and by ethologists, was quite undreamt of.

The latest example of this is the experimental demonstration by P. Sauer and E. Sauer (*13*) that certain warblers that migrate by night (for example, blackcap and garden warbler) can maintain orientation only if they have a clear view of the starlit sky. They seem able to do this even if they have been hand-reared and have never seen the sky prior to the experiment, the present implication being that they have an innate releasive mechanism attuned to certain features of the seasonal star pattern of the Northern Hemisphere.

The innate coding of such organizations in germ plasm and higher nervous centers poses even tougher problems for geneticist and neurologist than does the existence of fixed-action-patterns. With the latter there is always the possibility that proprioceptive feedback or reafference can, on the chain reflex principle, provide at least some of the explanation, whereas in much of the former this is hardly conceivable.

STUDIES OF BIRD SONG

Another example of the ability to perceive complex patterns and, further, to develop complex actions by elaborate learning processes by, so to speak, building upon the inborn recognition of such patterns, is provided by the studies of bird song which we have been carrying out for some years now at the Madingley Ornithological Field Station of the Cambridge University department of zoology (*14*). Here the pattern perceived is a temporal pattern of sound, and the complex actions guided by it, and developed therefrom, are the actions of singing the song. Although call notes are usually stereotyped and inborn, it has long been suspected that learning plays some part in the production of the full song of songbirds, for the imitative abilities of birds such as the bullfinch, starling, mockingbird, and parrot are known to all. Nevertheless, in some species (for example, the corn bunting, reed bunting, and some species of warbler) the normal characteristic full song is entirely inborn. More interesting, for present purposes, are those species, such as the chaffinch, linnet, and yellow bunting, in which the basic pattern of the song is innate, but all the fine detail and much of the pitch and rhythm have to be learned. Thus the normal chaffinch song consists of three more or less well marked phrases, ending in a final flourish. If, now, one takes young chaffinchs from the nest and rears them by hand, individually, in a soundproof room, or at least out of hearing of all chaffinch song, there is no longer any division into separate phrases, although the song is about the right length and there is a tendency for some birds to conclude their utterance with a single, simple note of higher pitch than the rest — a sort of squeak. This, then, seems to represent the inborn inherited basis of the chaffinch song. If, however, after rearing such birds through babyhood, we keep two or more of them together (although still under conditions such that they never have the opportunity to hear experienced chaffinches), a very big difference becomes apparent when they commence singing in earnest, at about the age of 9 months. Although their inborn songs are so simple, yet the attempt to sing these in company provides a mutual stimulation which encourages the production of complexity. As a result of mutual imitation, each of such birds or groups of birds will build up a distinctive community pattern. Many experiments have now shown that there is a period of about 6 weeks' duration or less, at about the 11th month of life (when the bird is for the first time in its life in the physiological state appropriate for territorial song), when the full song is learned. Once this time has passed, the song is fixed for life, and it does not matter to how much wild chaffinch song such birds are now exposed — year after year they will sing only the song which they worked out for themselves as youngsters. These and many other similar experiments make it clear what is happening in the wild. Young chaffinches must certainly learn some details of song from their parents or other adults in the first few weeks of life. For instance, they learn at this stage that the song "should" be divided into two or three phrases and "should" end with a more or less elaborate flourish. But the learning of all the finer details of song is postponed by the wild bird, just as by the experimental birds, until the advent of the critical period during the following spring. This is the time when the young chaffinch in the wild is first singing in a territory in competition with neighboring birds of the same species, and we have good evidence that wild birds learn the finer details of the song from their immediate neighbors. There is little doubt that it is primarily in this way that local song dialects, which so many field naturalists have noted, are built up and maintained. The young chaffinch thus learns the details of its full song by listening to older, experienced chaffinches. How it is that it does not also imitate and acquire the songs of other species we do not yet know for certain — probably by restricting its imitative attention to models of the right tonal quality. With the more generally imitative species there is evidence for what one must at present describe as imitation for its own sake. A chaffinch may presumably gain some advantage in its competition for maintenance of territories by being able quickly to modify its song so as to resemble that typical of the locality, but many species more proficient as songsters, and more generally imitative, seem to effect what can only be described as elegant improvisation, and the biological function of this and of the more extreme forms of vocal imitation is very difficult to assess. It seems that true vocal imitation must be regarded as a late development from inherited song patterns and must be looked on as characteristic of the most highly evolved among the true songbirds. It is hard to find any selective reason for the extreme purity and elaboration of some bird notes and songs. Releaser function appears in many cases to have been transcended. This feature has suggested to several authors that, in the finer details of songs, we see the beginnings of true artistic creation, and there is certainly no justification for ruling out such a hypothesis as fantastic or absurd. But perhaps tonal purity, inventiveness, and imitative ability are all examples of "preadaptation" for apparently remote and unlikely contingencies, specialization coming in advance of immediate adaptive requirements.

If this is true, such vocal performances are on a par with the number-sense which can be developed in many species of birds by careful training. The brilliant and painstaking work of Otto Koehler and his associates on the recognition of number by birds is one of the most remarkable developments in recent years in the study of animals' learning ability. Pitfalls in such experiments are numerous and extremely difficult to avoid, and only by the most careful experimental design and extreme pertinacity can the danger of "Clever Hans" errors be avoided. To do this was an experimental achievement of the highest class, and as a result we now know that some birds can "count" up to seven. Such counting ability seems to offer even less practical advantage for a wild bird than the features of song improvisation and imitation. Both are as yet set about with much mystery.

When we look at achievements such as the learning of elaborate songs and the other examples of animal behavior we have just been considering, we realize that the distinction between appetitive behavior and consummatory act has indeed become very tenuous. This is further illustrated by experiments on the following-response of young birds such as moorhens and coots. Here the very act of following a model, or the parent, has been shown (*15*) to be both appetitive and consummatory. This following, which is the active maintenance of a certain spatial relation to a chosen object, turns out to be its own reward; in other words, it is the maintenance of this spatial relationship which is the reinforcement. Similarly with the imitative birds, the very act of imitating, the very fact of achieving the appetitive behavior, seems itself to be the consummatory act.

INSIGHT AND INSIGHT-LEARNING

In the foregoing examples of recent studies of animal behavior, we see, then, numerous instances of more or less elaborate, inborn releasive mechanisms guiding and restricting learning. We see inborn mechanisms developed by learning processes into perceptual and behavioral complexes of extraordinary elaboration, and we find, in insects and birds, instance after instance of the ability to perceive not simple sense data but relations between perceptions both simple and complex. These faculties are in fact what have — since the coming of the Gestalt school — become known as insight and insight learning. There is still, of course, plenty of room for trial-and-error; these newer results do little to diminish its importance in the story. But completely unreflective trial-and-error — what Lloyd Morgan would have called *perceptive* trial-and-error — only, with no fore-plan or insight entering into the picture at all, is probably insufficient to account for behavior in animals where there is any evidence of elaborate perceptual organization. It seems to me inescapable that much modern work on animal behavior implies that the vast majority of metazoan animals are perceptive. Moreover, in all highly organized perceptions, the perception of relations involved implies something more. This, Lloyd Morgan would have taken to be self-consciousness. For Lloyd Morgan, the perceptive mind is conscious, but only the reflective type of mind is self-conscious — a distinction which sounds somewhat dated to our ears but which is nevertheless worth remembering. Insight learning can be defined, in Lloyd Morgan's phraseology, as action as a result of insight, by reflective organization, giving a new adaptive response, and a great deal of the modern evidence for insight-learning, imitation, play, number sense, and reminiscence gives reasons for considering animals to be reflective in his sense. Present-day students of animal behavior tend, not without reason, to avoid the word *consciousness*, and to perform displacement actions indicative of extreme anxiety whenever it is used with reference to animals. And we must indeed remember that perhaps Freud's most enduring claim to fame was his demonstration of the existence of highly elaborate mental processes far below the normally conscious level (*16*). Yet we are justified in using consciousness as a provisional biological hypothesis whenever we find directive behavior of such complexity that it cannot be fully or reasonably explained by mechanisms known to be operating within the body of the animal. Of course, if we can point to an efficient mechanism, that does not mean that true conscious-purpose is necessarily absent, even though, as practicing scientists, we may decide that, for the time being at any rate, it is no longer our concern.

I think, further, that the modern developments in the study of the higher-learning faculties of animals have served to emphasize the necessity for getting back to the idea of a carefully thought out combination of objective and subjective approach exemplified by Lloyd Morgan. The best instruments can be misused, and it is possible to cut our throats with Occam's razor and to disintegrate our animals with a blast from Lloyd Morgan's canon. If we try too rigidly to be objective, we may fail to see many important features of animal behavior which become clear to us when we attempt to put ourselves in the animal's place. While, of course, to go to the other extreme and be too subjective in approach is fatal — we must safeguard ourselves all the time with all the knowledge we have of the animal's sensory and behavioral capabilities. But I am convinced that a proper balance of the subjective and the objective is necessary both for a worthy ethology and a worthy psychology. Pure objectivity on the part of an external observer is in any case hardly feasible and, if achieved, will result in the neglect of much that is important. Perhaps it is excusable here to paraphrase and adapt some remarks of Lorenz (*17*) without, I hope, changing their essential meaning: "The true ethologist must be motivated not merely by a conscious effort to gain knowledge; for unless his eyes are bound to the object of his studies by that spellbound gaze, that sympathy which is evidenced by the mysterious charm that the beauty of living creatures works on some of us, he would be physically incapable of bringing himself to stare with sufficient persistence at fish, birds or mammals as is necessary to take stock of the behavior patterns of a species." If ethologists are right, then, that the guarded subjective approach (implying, as it does, something of the viewpoint of the artist) is one essential method in acquiring knowledge of animal nature, I believe it will ultimately be found that we have here a most important argument in support of those who conclude, as for instance does Erroll Harris (*18*) (from a vast knowledge of scientific advance and scientific philosophy), that empiricism, however necessary as a scientific technique, cannot possibly — from the nature of the case — supply an adequate scientific philosophy. But for a biologist this is treading on dangerous ground and I leave it hastily!

ESSENTIAL UNITY OF LIVING THINGS

Finally we may ask, does this recent work on instinctive behavior and the percipient learning abilities of animals give us any fresh view of animal nature? The answer is, I think, undoubtedly that some apparent lines of demarcation between man and animal nature have become blurred. The fact just referred to, that so many animals in certain situations give evidences of being "reflective," in Lloyd Morgan's sense, and that, in so many cases, exploratory behavior, the mere getting to know an environment, is itself adequate reward, at once suggests resemblances with man. Many higher animals resemble man in their tendency to achieve consummatory situations rather than consummatory acts. The occurrence of displacement actions in many animals when under the influence of conflicting instinctive drives shows remarkable superficial similarity to the effects of the conflict of learned or acquired drives (habits) in man. Animals suffering from "conflict" recall neurotic human beings in the same state to a degree that is often quite startling. Behavior study seems then to be reinforcing physiology in stressing the basic unity of the living system in more and more of its manifestations. Some of the fundamental thought processes of animals seem far less dissimilar from ours than we once thought, and we now see that even the bees have a propositional language, as distinct from the mere emotive influence which is the sole result of the language of so many animals — though of course there is no justification for assuming that the bees' communication is consciously intentional as is that of true human language. Propositional language was, until recently, thought to be the prerogative of human beings, and human language still seems to be unique in that it implies learning to use, as symbols, sounds or actions which in themselves have nothing of the *quality* of the objects which they denote (for example, number symbols).

But we may ask, further, does the modern study of animal behavior reinforce or run counter to the general trend of progress in other branches of biology? In the first place, I think it true to say that it is the conclusion of many and various disciplines that the world of living things appears now as far more of a unity than was conceivable 100 years ago. The post-Darwinian era in research has tended, on the whole, to break down barriers alike between phyla and between individual disciplines, and the same fundamental general principles are seen to be operating fairly widely through the animal and plant kingdom. Even the bacteria and the viruses, for all their strangeness, seem less remote than they once did. Apart from his famous canon, Lloyd Morgan's real claim to immortality is his development of the idea of emergent evolution and the contribution his thinking made to the concept of holism. Moreover, he wrote at a time when the boundary line between living and non-living seemed as well defined as the English Channel. But how different it now is; a subtle change has manifested itself. It is not that analysis into ever finer levels of structure and physiology is showing progressively that biology is, after all, only the complicated physics and chemistry of an earlier generation. Far from it! To quote L. E. R. Picken (*19*): "The hope that analysis to ever finer levels of structure will ultimately reveal the nature of that relation by virtue of which the whole is more than the sum of the parts, has now been shown to be in vain. Most experimental biologists have, in the past, worked on the tacit or explicit belief that analysis in the terms of the physics and chemistry of fifty years ago — the physics of matter *en masse*, the chemistry of small molecules — would yield the answer. But we can see now that the physics and chemistry are going to be those of ordered aggregates far larger than molecules. The extent to which the concepts of chemistry and of physical chemistry have been modified sometimes almost out of existence — as in the case of the concept of the molecule — by contact with biological material is of the greatest historical importance." Increasingly, biological organization now seems apparent in circumstances and conditions where, not so long ago, all was thought to be physics and chemistry, and it seems not improbable that future advance may come by starting with concepts derived from the biological sciences and working back into the physical sciences. In fact the present position of biological philosophy is one which Lloyd Morgan foresaw, and some of his statements can be lifted right out of their former contexts and used in present-day writing without seeming in the least out of date.

Ethology has as yet little, itself, to say on this fundamental issue of living and nonliving, but it does make an impressive contribution to the chorus of voices which are emphasizing the essential unity of living things and the similarity, in much that is fundamental, between animals and man. But while this is true it would be a view of the utmost naïveté to assume that studies of animal behavior imply any decrease in the stature of man. For it is sound scientific common sense to see that, if only because of the existence of science itself, man displays emergent qualities far transcending those of the organisms most nearly related to him. Moreover, his high powers of abstract reasoning, his faith, the depths of his spiritual life, his appreciation of moral values, his self-conscious discipline of the will to achieve abstract values, not only differentiate him from the animals; these and all the other manifestations which have already emerged suggest that he possesses vast further potentialities yet to be realized in both individual and evolutionary development.

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SUGGESTIONS FOR FURTHER READING

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PART VI Behavior Is Dynamic

MAN, LIKE OTHER ORGANISMS, EXHIBITS SOME BEHAVIOR WHICH IS MACHINELIKE, that is, stereotyped. Such simple acts as reflexes are comparatively fixed in their patterning. As with a coin-in-the-slot candy dispenser, you press the button (stimulus) and out comes the product (response). But less of man's behavior is of the machine sort than is the case in behavior of lower animals; it is the adaptive (Part III), the variable (Part IV), and the gradually developed (Part V) behavior which is more interesting and less fixed. Part VI deals with the behavior we call dynamic and serves to give unity and organization to those behaviors previously discussed.

When a psychologist says that behavior is dynamic, he means that it is impelled by forces — many forces which are in complex relationships to each other and to the individual behaving. The forces have been described as "the mainsprings of action," "internal energizers," or "propelling actions." Dynamic behavior is also time-patterned through a series of steps beginning with a need and terminating at a goal. Several such patterns operate simultaneously; some may be brief, whereas others continue for years; some show powerful force, whereas others are weak; some are inborn, and others are learned; movement toward the goal is sometimes direct and decisive, but it is often meandering or subtle. If the needs which originate our behavior help us to understand the "why," then we must examine such sources in order to clarify the notion of motivation.

Human needs are of three sorts; biological needs, which direct us to activity contributing to physical health and the maintenance of life; social needs, which direct us toward a role in the community and a healthful society; and personal needs, which contribute to our uniqueness as an individual, our worth, and our mental health. We share a great similarity of biological needs because of membership in the same species; we share less, but still much, similarity of social needs because of our common culture; and we share still less similarity of personal needs inasmuch as our experiential biographies differ one from another to a considerable degree.

One's whole life is a sequence of segments of goal-directed behavior, different segments interlocking, terminating, linking, temporarily shelved, blocked, facilitated, slowed, inhibited, and otherwise varied in constantly shifting mosaics. When the goal is immediately apparent and the movement toward it is unopposed, behavior is simple, but we inevitably experience counter forces in the form of opposition. These are barriers — physical or symbolic — or conflict situations having opposite and simultaneous motives. Such frictions, then, lead to adjustments or to frustrated, tense, or anxious behavior patterns.

Selections in Part VI deal with some of the more involved aspects of the dynamics of behavior, rather than with the fundamental concepts of needs, adjustments, and goals. Heron reports some pioneering studies in the integration of behavior by general stimulation. Hall is interested in the way dreams may be used to get at the way a person thinks about his own motivations. In the third selection, Jacob reports data which relate to motivation and the learning of values in higher education. Implications for reducing social stress through motivation control are suggested by Flugel in the next selection. Psychoanalysis as a system for describing and understanding human dynamics is taken up in the next two selections. Finally, we consider the consequences of motivated behavior which is not goal-achieving, because of a loss of ability to control the environment (selection 42) and experimentally induced failures (selection 43).

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The Pathology of Boredom

WOODBURN HERON

Stimuli are those energies within us and about us which excite receptor organs and thus initiate behavior, but they are much more than mere trigger actions. The dynamic role of stimulation was shown in a series of brilliant studies conducted in recent years at McGill University under the direction of D. O. Hebb. Some of these investigations are described in this article by one of Hebb's associates. Absence or sharp reduction of stimulation over several hours results in a deterioriation of judgment and critical ability. Hallucinations, like feverish dreams, are induced, and childish emotionality is exhibited. Subjects are unable to maintain motivation for reviewing their studies, or for recollecting past events, or even for so simple a task as counting. Concentration becomes unbearable. Some psychologists believe that we are just beginning to understand the dynamic role of general stimulation in the maintenance of motivation.

Dr. Heron obtained his PhD degree at McGill and is now assistant professor of psychology there. The following article appeared in *Scientific American* in January, 1957 (pp. 52–56). It is reprinted by permission of the publisher.

If you shake the surface on which a snail is resting, it withdraws into its shell. If you shake it repeatedly, the snail after a while fails to react. In the same way a sea anemone which is disturbed by a drop of water falling on the water surface above it ceases to be disturbed if drops continue to fall; a bird stops flying away from a rustling motion if the motion is steadily repeated. Most organisms stop responding to a stimulus repeated over and over again (unless the response is reinforced by reward or avoidance of punishment). Indeed, the higher organisms actively avoid a completely monotonous environment. A rat in a maze will use different routes to food, if they are available, rather than the same one all the time. It will tend to avoid areas in which it has spent considerable time and to explore the less familiar areas.

Monotony is an important and enduring human problem. Persons who have to work for long periods at repetitive tasks often complain of being bored and dissatisfied with their jobs, and frequently their performance declines. During the last war N. H. Mackworth of England made a series of researches for the Royal Air Force to find out why radar operators on antisubmarine patrol sometimes failed to detect U-boats. The operators usually worked in isolation, watching a radar screen hour after hour. Mackworth set up a comparable laboratory situation, requiring subjects to watch a pointer moving around a graduated dial and to press a button whenever the pointer made a double jump. The subjects' efficiency declined in the surprisingly short time of half an hour. As a result of this and other research the radar operators' tour of duty was shortened.

In this age of semi-automation, when not only military personnel but also many industrial workers have little to do but keep a constant watch on instruments, the problem of human behavior in monotonous situations is becoming acute. In 1951 the McGill University psychologist D. O. Hebb obtained a grant from the Defense Research Board of Canada to make a systematic study of the effects of exposure for prolonged periods to a rigidly monotonous environment. Hebb's collaborators in the project were B. K. Doane, T. H. Scott, W. H. Bexton and the writer of this article.

The aim of the project was to obtain basic information on how human beings would react in situations where nothing at all was happening. The purpose was not to cut individuals off from any sensory stimulation whatever, but to remove all patterned or perceptual stimulation, so far as we could arrange it.

The subjects were male college students, paid $20 a day to participate. They lay on a comfortable bed in a lighted cubicle 24 hours a day for as long as they cared to stay, with time out only for meals (which they usually ate sitting on the edge of the bed) and going to the toilet. They wore translucent plastic visors which transmitted diffuse light but prevented pattern vision. Cotton gloves and cardboard cuffs extending beyond the fingertips restricted perception by touch. Their auditory perception was limited by a U-shaped foam rubber pillow on which their heads lay and by a continuous hum of air-conditioning equipment which masked small sounds.

When we started the research we were not at all sure what aspects of behavior it would be most profitable to investigate. Accordingly we began with a preliminary run in which we merely observed the subjects' behavior and interviewed them afterward. Most of these subjects had planned to think about their work: some intended to review their studies, some to plan term papers, and one thought that he would organize a lecture he had to deliver. Nearly all of them reported that the most striking thing about the experience was that they were unable to think clearly about anything for any length of time and that their thought processes seemed to be affected in other ways. We therefore decided that the first thing to do was to test effects on mental performance.

We used three main methods of investigating this. One was a battery of oral tests involving simple arithmetic, anagrams, word association and so on. This battery was given before the experiment, at 12, 24 and 48 hours during the isolation and finally three days afterward. Another battery of tests, given two days before and immediately after the isolation period, included copying a design with blocks, speed of copying a prose paragraph, substituting symbols for numbers, picking out what was odd in each of a series of pictures (for instance, one picture showed a man in a canoe using a broom instead of a paddle) and recognizing patterns embedded in a complex background. The third test used a recording of a talk arguing for the reality of ghosts, poltergeists and other supernatural phenomena. It was played to each subject during his isolation. We examined the individual's attitude toward supernatural phenomena before he entered isolation and after he had emerged.

On almost every test the subjects' performance was impaired by their isolation in the monotonous environment (and was poorer than that of a control group of students). The isolation experience also tended to make the subjects susceptible to the argument for the existence of supernatural phenomena. Some of them reported that for several days after the experiment they were afraid that they were going to see ghosts.

As the subjects lay in isolation, cut off from stimulation, the content of their thought gradually changed. At first they tended to think about their studies, about the experiment, about their personal problems. After a while they began to reminisce about past incidents, their families, their friends and so on. To pass the time some tried to remember in detail a motion picture they had seen; others thought about traveling from one familiar place to another and would try to imagine all the events of the journey; some counted numbers steadily into the thousands. (Incidentally, such experiences are commonly reported by persons who have been in solitary confinement for long periods.) Eventually some subjects reached a state in which it took too much effort to concentrate, and they became "content to let the mind drift," as one subject put it. Others said: "My mind just became full of sounds and colors, and I could not control it"; "I just ran out of things to think of"; "I couldn't think of anything to think about." Several subjects experienced "blank periods" when they did not seem to be thinking at all.

Not surprisingly, the subjects became markedly irritable as time went on and often expressed their irritation. Yet they also had spells when they were easily amused. In the interview afterward many of the subjects expressed surprise that their feelings could have oscillated so much, and that they could have behaved in such a childish way. They also said that they seemed to lose their "sense of perspective" while in the cubicle, and some subjects mentioned that at times they felt that the experimenters were against them, and were trying to make things exceptionally tough for them.

The subjects reported something else to which we at first paid no particular attention, but which was to emerge as the most striking result of the experiments. Many of them, after long isolation, began to see "images." One man repeatedly saw a vision of a rock shaded by a tree; another kept on seeing pictures of babies and could not get rid of them. Several subjects seemed to be "having dreams" while they were awake. Not until one of the experimenters himself went through the isolation experience for a long period did we realize the power and strangeness of the phenomenon. His report, and a review of the literature on other experiments in monotony, made clear that the experimental situation induced hallucinations.

The visual phenomena were similar to those experienced after taking the intoxicating drug of the mescal plant (mescal buttons), which is a ceremonial practice of some Indian tribes in the Southwest. They have also been reported in experiments in which subjects were exposed for long periods to blank visual fields or flickering light.

Our subjects' hallucinations usually began with simple forms. They might start to "see" dots of light, lines or simple geometrical patterns. Then the visions became more complex, with abstract patterns repeated like a design on wallpaper, or recognizable figures, such as rows of little yellow men with black caps on and their mouths open. Finally there were integrated scenes: e.g., a procession of squirrels with sacks over their shoulders marching "purposefully" across the visual field, prehistoric animals walking about in a jungle, processions of eyeglasses marching down a street. These scenes were frequently distorted, and were described as being like animated movie cartoons. Usually the subjects were at first surprised and amused by these phenomena, looked forward eagerly to see what was going to happen next and found that the "pictures" alleviated their boredom. But after a while the pictures became disturbing, and so vivid that they interfered with sleep. Some of the subjects complained that their eyes became tired from "focusing" on the pictures. They found sometimes that they could even scan the "scene," taking in new parts as they moved their eyes, as if they were looking at real pictures.

The subjects had little control over the content of the hallucinations. Some kept seeing the same type of picture no matter how hard they tried to change it. One man could see nothing but dogs, another nothing but eyeglasses of various types, and so on. Some subjects were able to realize visions of objects suggested by the experimenter, but not always in the way they were instructed. One man, trying to "get" a pen, saw first an inkblot on a white table cloth, then a pencil, then a green horse, finally a pen.

The hallucinations were not confined to vision. Occasionally a subject heard people in the "scene" talking, and one man repeatedly heard a music box playing. Another saw the sun rising over a church and heard a choir singing "in full stereophonic sound." Several subjects reported sensations of movement or touch. One had a feeling of being hit in the arm by pellets fired from a miniature rocket ship he saw; another, reaching out to touch a doorknob in his vision, felt an electric shock. Some subjects reported that they felt as if another body were lying beside them in the cubicle; in one case the two bodies overlapped, partly occupying the same space. Some reported feelings of "otherness" or "bodily strangeness"; trying to describe their sensations, they said, "my mind seemed to be a ball of cotton wool floating above my body," or "something seemed to be sucking my mind out through my eyes."

After emerging from isolation, our subjects frequently reported that "things looked curved," "near things looked large and far things looked small," "things seemed to move," and so on. We therefore made some systematic tests of their visual perception. The most striking finding was that when subjects emerged after several days of isolation, the whole room appeared to be in motion. In addition there was a tendency for surfaces to appear curved, and for objects to appear to be changing their size and shape. Asked to match a disk that was handed to them to one in a row of disks of various sizes 12 feet away, the subjects consistently chose a larger disk than did control subjects.

We recorded changes in the electrical activity of the brain in these subjects by means of electroencephalograms made before, during and after the isolation period. There was a tendency for some slow waves, which are normally present in sleep but not when an adult is awake, to appear after a period of isolation. In addition, the frequencies in the region of the principal brain rhythm slowed down.

The overt behavior of the subjects during the experiment was, of course, carefully recorded. Most of the subjects went to sleep fairly soon after they had been placed in the cubicle. After waking they showed increasing signs of restlessness. This restlessness was not continuous but came in more and more intense spells, which were described as being very unpleasant. The subjects appeared eager for stimulation, and would talk to themselves, whistle, sing or recite poetry. When they came out for meals, they tended to be garrulous and attempted to draw the experimenters into conversation. In moving about, as when they were led to the toilet, they appeared dazed and confused, and had increasing difficulty in finding their way about the washroom.

As an outgrowth of the general experiment, we have begun some tests to find out the effects of restriction of just one sense. We tested six subjects who wore the frosted visors constantly but who otherwise were allowed to pursue comparatively "normal" activities. Unfortunately the results of this experiment are not "pure," because the restriction of vision greatly restricted their movements and opportunity for other stimulation. These subjects developed visual hallucinations and also experienced some disorders of visual perception when the visors were removed.

Prolonged exposure to a monotonous environment, then, has definitely deleterious effects. The individual's thinking is impaired; he shows childish emotional responses; his visual perception becomes disturbed; he suffers from hallucinations; his brain-wave pattern changes. These findings are in line with recent studies of the brain, especially of the reticular formation in the midbrain. In some way the reticular formation regulates the brain's activity. The recent studies indicate that normal functioning of the brain depends on a continuing arousal reaction generated in the reticular formation, which in turn depends on constant sensory bombardment. It appears that, aside from their specific functions, sensory stimuli have the general function of maintaining this arousal, and they rapidly lose their power to do so if they are restricted to the monotonously repeated stimulation of an unchanging environment. Under these circumstances the activity of the cortex may be impaired so that the brain behaves abnormally.

The results of our experiments seem to throw light on a number of practical problems. For instance, studies in France and at Harvard University have indicated that hallucinations are fairly common among long-distance truck drivers. After many hours on the road they may begin to see apparitions such as giant red spiders on the windshield and nonexistent animals running across the road, which frequently cause accidents. Similar phenomena have been reported by aviators on long flights: Charles Lindbergh described some in his autobiography. It is not improbable that some unexplained airplane and railroad accidents have been occasioned by effects of prolonged monotonous stimulation.

A changing sensory environment seems essential for human beings. Without it, the brain ceases to function in an adequate way, and abnormalities of behavior develop. In fact, as Christopher Burney observed in his remarkable account of his stay in solitary confinement: "Variety is not the spice of life; it is the very stuff of it."

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What People Dream About

CALVIN S. HALL

Dreams have been interpreted for many purposes, from party entertainment to serious scientific study, for dreams are fascinating bits of our personal experience. Dream analysis has been attempted by pseudoscientists and by legitimate scientists, especially by the psychoanalysts. Not until the studies reported here has anyone obtained sufficient dream data from normal adults to establish a firm body of facts upon which a theory could be developed. The systematic description which Hall presents is a necessary first step toward the eventual understanding of this curious type of behavior. Hall differs from Freud in his hypothesis that dreams reveal how the dreamer views his own conflicts and motivational tendencies. He believes the role which the dreamer takes in his "sleep thinking" is indicative of the self-regarding traits of personality. Notice how often in dreams the players and places are related to persons and scenes with which the dreamer is emotionally involved in his waking life.

Dr. Hall has been professor of psychology at Western Reserve University for over twenty years. He formerly taught at the University of California and the University of Oregon. This article on dreams appeared in *Scientific American* for May, 1951 (pp. 60–63), and is reprinted by permission of the publisher.

Man's dreams have always interested and perplexed him. From ancient times and from every civilization and culture, we have evidence of man's concern about the meaning of dreams. They have been interpreted variously as divine messages, as the experiences of disembodied souls roaming heaven and earth during sleep, as visitations from the dead, as prophecies of the future, as the sleeping person's perceptions of external stimuli or bodily disturbances (what Thomas Hobbes called "the distemper of inward parts"), as fulfillments or attempted fulfillments of wishes (Freud), as attempts by the dreamer to discern his psychic development in order to plan for the future (Jung), as expressions of one's style of life (Adler), as attempted resolutions of conflicts (Stekel).

Probably all of these theories, however ancient their origin and however nebulous their validity, have their votaries today. Dream books based on the theory that dreams foretell the future are undoubtedly as widely consulted today as they were during the Renaissance, when the dream book compiled by the second-century soothsayer Artemidorus was republished in many languages and editions, and was plagiarized and elaborated by numerous opportunists, who in that day as in this knew a good thing when they saw it.

Even in modern times speculations about dreams have been long on theory and short on observation. What do people dream about? What is the content and character of their dreams? As far as I know, no one has made an extensive and systematic study of these questions. To be sure, psychoanalysts have given much careful analysis to the dreams of deranged and disturbed persons, but even for this unrepresentative segment of mankind there are no large-scale surveys of the content of their dreams.

The writer has undertaken to make such a survey, for the purpose of obtaining some empirical facts as a foundation for theorizing. He has collected more than 10,000 dreams thus far, not from mental patients but from essentially normal people. They were asked to record their recollection of each dream on a printed form which included questions requesting certain specific information, such as the setting of the dream, the age and sex of the characters appearing it it, the dreamer's emotions and whether the dream was in color. Obviously we cannot know how faithfully the subjects' recollections mirrored their actual dreams, so strictly speaking we should call our project a study of what people *say* they dream about. This has ever been the case and probably always will be, for no one has discovered a means of transcribing a dream while it is being dreamed.

We classified the dream material so that it could be studied statistically. From the many possible methods of classification we chose, as a beginning, a simple breakdown into five fundamental categories: (1) the dream setting, (2) its cast of characters, (3) its plot, in terms of actions and interactions, (4) the dreamer's emotions, and (5) color.

What are the most common settings in people's dreams? An analysis of 1,000 dreams reported by a group of educated adults provided 1,328 different settings. These could be classified into 10 general categories. The most frequent scene was a part of a dwelling or other building; this accounted for 24 per cent of all dreams. The other settings, in order of frequency, were: a conveyance of some kind, most commonly an automobile, 13 per cent; an entire building, 11 per cent; a place of recreation, 10 per cent; a street or road, 9 per cent; a rural or other outdoor area, 9 per cent; a store or shop, 4 per cent; a classroom, 4 per cent; an office or factory, 1 per cent; miscellaneous (including restaurants, bars, battlefields, hospitals, churches, and so on), 14 per cent. In dreams occurring in part of a dwelling the most popular room is the living room, with the bedroom, kitchen, stairway and basement following in order.

The outstanding feature of these dream settings is their commonplaceness. The typical dream occurs in prosaic surroundings — a living room, an automobile, a street, a classroom, a grocery store, a field. The dreamer may not always recognize the details of the place, but usually it is a type of scene with which he is familiar; seldom does he dream of a bizarre or exotic environment. Yet dream settings apparently are not entirely representative of waking life, as far as frequency is concerned. Considering the amount of time that people spend in places of work, such as offices, factories and classrooms, these places appear with disproportionately low frequency in dreams. On the other hand, conveyances and recreational places occupy a larger share in dreams than they do in waking life experiences. In other words, in our dreams we tend to show an aversion toward work, study and commercial transactions and an affinity for recreation, riding and residences.

For a study of characters appearing in dreams, we divided our subjects into two groups according to age, since it seemed likely that older people might differ from younger ones in the persons they dreamed about. The younger group was aged 18 to 28, the older 30 to 80. Let us consider the younger group first. They furnished a total of 1,819 dreams. In 15 per cent of these the only character was the dreamer. In the remaining 85 per cent, in which two or more characters appeared, the average number was two persons besides the dreamer.

Who are these characters? Of the persons other than the dreamer, 43 per cent appeared to be strangers, 37 per cent were identified as friends or acquaintances of the dreamer, 19 per cent were family members, relatives or in-laws, 1 per cent were famous or prominent public figures. The relatively infrequent appearance of prominent persons in dreams supports other evidence possessed by the writer that dreams rarely concern themselves with current events. Among the members of the family, the character that appears in dreams most often is mother (34 per cent); then come father (27 per cent), brother (14 per cent) and sister (12 per cent).

We also classified the characters in dreams by sex and age. It turns out that men dream about males twice as often as they do about females, whereas women dream almost equally about both sexes. In the dreams of both men and women 21 per cent of the characters are not identified as to sex.

The analysis showed, as is not surprising, that people dream most often about other people of their own age. In the sample of dreams from the subjects in the 18-to-28 age group, 42 per cent of the dream characters were the dreamers' peers in age, 20 per cent were older, 3 per cent were younger and 35 per cent were of unspecified age.

We found that in general there were no very pronounced differences between the characters in the dreams of the young and older groups. Older people dream more about family and relatives and less about friends and acquaintances, which is not very surprising, since the younger dreamers were for the most part unmarried. Older people also dream more about younger characters and less about older characters and peers than do younger dreamers. We may generalize our findings by saying that while children are dreaming about their parents, their parents are dreaming about them, and while husbands are dreaming about their wives, their wives are dreaming about them.

We come now to actions or behavior: What do people do in their dreams? We classified 2,668 actions in 1,000 dreams. By far the largest proportion (34 per cent) fall into the category of movement — walking, running, riding or some other gross change in bodily position. We found that, contrary to popular belief, falling or floating in dreams is not very common. After movement, the next most common activities were talking (11 per cent), sitting (7 per cent), watching (7 per cent), socializing (6 per cent), playing (5 per cent), manual work (4 per cent), thinking (4 per cent), striving (4 per cent), quarreling or fighting (3 per cent), and acquiring (3 per cent). From this it can be seen that passive or quiet activities occupy a large part of dreams, while manual activities are surprisingly infrequent. Such common waking occupations as typing, sewing, ironing and fixing things are not represented in these thousand dreams at all; cooking, cleaning house, making beds and washing dishes occur only once each. But strenuous recreational activities, such as swimming, diving, playing a game and dancing, are fairly frequent. In short, dreamers go places more than they do things; they play more than they work; their activities are more passive than active.

What of the relations between the dreamer and the other characters in his dream? We classified the interactions in a sample of 1,320 dreams in various categories according to degrees of friendliness or hostility. In general, hostile acts (by or against the dreamer) outnumbered friendly ones 448 to 188. In the hostile sphere the acts of aggression ranged from murder (2 per cent) and physical attack (28 per cent) to denunciation (27 per cent) and mere feelings of hostility (8 per cent). The friendly acts ranged from an unexpressed feeling of friendliness to the giving of an expensive gift.

The emotions felt by dreamers during their dreams were recorded in five classes: (1) apprehension, including fear, anxiety and perplexity; (2) anger, including frustration; (3) sadness; (4) happiness, and (5) excitement, including surprise. Apprehension predominated, accounting for 40 per cent of all dream emotions; anger, happiness and excitement were tied with 18 per cent each, and sadness was the least frequent, 6 per cent. Thus 64 per cent of all dream emotions were negative or unpleasant (apprehension, anger, sadness) and only 18 per cent (happiness) were positively pleasant.

Yet paradoxically in the judgment of the dreamers themselves the dreams as a whole were rated pleasant much more often than unpleasant. They found 41 per cent of the dreams pleasant, 25 per cent unpleasant, 11 per cent mixed and 23 per cent without feeling tone. Older dreamers reported more unpleasant dreams than younger ones, but the difference was not great.

A question that has puzzled many students of dreams is why some of them are seen wholly or partly in natural colors ("technicolor"). I am afraid I have little to contribute to the solution of this puzzle beyond a few figures and a few negative conclusions. In a survey of over 3,000 dreams 29 per cent were colored or had some color in them and the rest were completely colorless. Women report color in dreams more often (31 per cent) than do men (24 per cent). There is a slight tendency for people over 50 to have fewer colored dreams than those under that age. Many people never experience color in dreams; on the other hand, a few have all their dreams in color.

What is the psychological significance of technicolored dreams? We have compared the dreams of people who dream entirely in color with those of people who never dream in color and have found no difference in any aspect of their dreams. We have compared the colored with the colorless dreams of the same person without discovering any way in which they differed. Nor can we find any single specific symbolic meaning in a particular color. We are forced to conclude on the basis of our present evidence that color in dreams is merely an embellishment, signifying nothing in itself.

What do all these facts on the content of dreams mean? I shall present my general theory of dreams and show how some of the foregoing findings fit into this theory.

Dreaming is thinking that occurs during sleep. It is a peculiar form of thinking in which the conceptions or ideas are expressed not in the form of words or drawings, as in waking life, but in the form of images, usually visual images. In other words, the abstract and invisible ideas are converted into concrete and visible images. By an odd process which we do not understand, the sleeping person can see his own thoughts embodied in the form of pictures. When he communicates his dream to another person, he is communicating his thoughts, whether he knows it or not.

During sleep we think about our problems and predicaments, our fears and hopes. The dreamer thinks about himself: what kind of person he is and how well fitted he is to deal with his conflicts and anxieties. He thinks about other people who touch his life intimately. His conceptions are purely egocentric; there appears to be no place in dreams for impersonal, detached thoughts. Accordingly the interpretation of dreams — the translation of the dreamer's images into his ideas — gives us an inner view of him, as though we were inside looking out and seeing the world as he sees it. We see how he looks to himself, how others look to him, and how he conceives of life. This is the heart of the matter, and the reason why dreams are important data for the psychologist.

How a person sees himself is expressed in dreams by the parts the dreamer plays. He may play the part of a victim or an aggressor or both; he may conceive of himself as winning in spite of adverse circumstances, or losing because of these same adversities. He may assume the role of a saint or a sinner, a dependent person or an independent one, a miser or a philanthropist. As Emerson said, "A skillful man reads his dreams for his self-knowledge."

Although the characters in his dreams are many and varied, they probably all have one thing in common — they are all emotionally involved in the dreamer's life. If this is so, one may well ask, why do we dream so often about strangers? The answer is that they are not really strangers but personifications of our conceptions of people we know. A person who conceives of his father as stern and autocratic, for example, may in his dreams turn his father into an army officer or a policeman or a schoolteacher or some other symbol of strict discipline. Very likely he will also have other conceptions of his father, and for each conception he finds an appropriate older figure who personifies the particular father conception uppermost in his mind at the time of the dream. Many of these father figures will be strangers to the dreamer, although the qualities expressed will be familiar enough to him.

Similarly the dream setting may portray the ways in which the dreamer looks at the world. If he feels that the world is closing in on him, he dreams of cramped places; if the world appears bleak, the dream setting is bleak. Tumultuous and tempestuous scenery — raging seas, milling crowds, exploding bombs, thunderstorms — betokens an outlook of insecurity and chaos. In one series of dreams studied by the writer there was a plethora of dirty, dank and dismal settings — a visible projection of the dreamer's conception of a world decaying.

Dreams are filled with the gratification or attempted gratification of impulses, particularly sexual and aggressive impulses. They tell us how the dreamer regards these impulses. If he thinks of sex or aggression as wicked, the expression of these impulses in his dreams will be followed by some form of punishment or misfortune. If he conceives of sex as a mechanical matter, he may have a dream like that of one young man who reported a nocturnal emission dream in which a lady plumber turned on a faucet for the dreamer. We study dreams, therefore, not to discover the wish motivating the dream, as Freud did, but rather to determine how the dreamer conceives of his wishes.

Dreams also provide a vista of the dreamer's conceptions of his conflicts. The dramatic quality of a dream — its plot, tensions and resolutions — is derived from an underlying conflict in whose grip the dreamer feels himself to be. In a series of dreams from the same individual we can see his conflict running like Ariadne's thread through the labyrinth of his dreams. The conflict may hang on with surprising tenacity over a period of years. Apparently the conflicts that motivate dreams are basic ones which rarely become resolved. We suspect that these internal wars have their origins early in life and are not easily, if ever, brought to a satisfactory conclusion.

In our studies of many dream series, a few conflicts stand out as being shared by many people. One such inner tug-of-war is that between the progressive pull of maturity, growth and independence and the regressive pull of infantile security, passivity and dependence. This conflict is particularly acute during adolescence and the late teens and early twenties, but in a large proportion of people it persists through later ages and returns to prominence in old age.

Another ubiquitous inner conflict is that between conceptions of good and evil — the moral conflict. The opposing forces are those of impulse and conscience. The dreamer impulsively kills a dream character and is then punished for his crime. Or he is driven to express sexuality for which he suffers some misfortune.

A third conflict arises out of the tug between the opposing tendencies toward integration and disintegration. By integration is meant all of the life-maintaining and love-encompassing aims of man; by disintegration, the forces of death, hate, fear and anxiety which produce disunity and dissolution. One pole affirms life and love, the other affirms death and hate. Anxiety dreams and nightmares express the conception of personal disintegration.

We study dreams in order to enlarge our understanding of man. They yield information that is not readily obtained from other sources. This information consists of man's most personal and intimate conceptions, conceptions of which not even the person himself is aware. It is important to know these conceptions, for they are the foundation of man's conduct. How we view ourselves and the world around us determines in large measure how we will behave.

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Does Higher Education Influence Student Values?

PHILIP E. JACOB

College and university faculties must occasionally appraise their objectives and achievements. The project which Dr. Jacob recently reported was one of the most ambitious of these self-examinations and also one of the most revealing. It is more than a little shocking to discover that the college experience seems to alter very little those motivational factors we call values. Whether this general failure is a lack of teaching skill or opportunity to learn, or is a matter of reluctance to change basic motivational patterns, is not revealed in this study; nor are the deeper questions of whether or not students should be changed, or whether colleges have the right to change them. Nevertheless, there is certainly a wide contrast between what teachers believe they should be doing and what these data indicate they are doing, with some few exceptions. These exceptional teachers, students, and institutions may be setting the pace for educational trends, or at least providing the social and intellectual leadership we so badly need. Especially important to students of psychology is the brief final part of this selection, which indicates that a motivational pattern developed before college age has a great deal to do with the returns the student receives on his investment in college.

Dr. Jacob is professor of political science at the University of Pennsylvania. He received his PhD degree from Princeton. This brief summary of his book appeared in the *NEA Journal* for January, 1958 (pp. 35–38), along with some critical reactions from three educators (which should be read too). Permission to reprint was obtained from the publisher and the author.

Colleges and universities must face a hard fact about their present accomplishment before they can plan realistically for their role in the not-too-distant future. For the most part, they seem to lack the capacity to influence students, or maybe today's students are incapable of being influenced by higher education.

In any case, a study of what happens to the values of American students of today shows that their college experience barely touches their standards of behavior, quality of judgment, sense of social responsibility, perspicacity of understanding, and guiding beliefs.

This means that if institutions of higher learning are expected to fulfil the historic humanistic mission of what we have called liberal education, they will have to learn how to do it. They are *not* doing it now with most of their students.

This conclusion stems from an analysis of three main types of data, which social scientists obtained from over 100 institutions: studies of student attitudes conducted during the last 15 years, recent evaluations of the outcomes of general education and other courses and of various methods of teaching, and a number of comprehensive self studies by particular institutions.*

Fortunately, not all evidence is negative. There are some institutions in which students' values seem to develop, some teachers whose influence penetrates and stays, and some educational techniques which help open the sensibilities as well as the intellectual perceptions of some students. But the prevailing situation concerning the influence of college on contemporary student values is as follows:

1. *The values of American college students are remarkably homogeneous, considering the variety of their backgrounds and their relatively unrestricted opportunities for freedom of thought and personal development.*

A dominant characteristic of the current student generation is that the students are gloriously contented, both in regard to their present day-today activity and their outlook for the future.

The great majority of students appear unabashedly self-centered. They aspire to material gratifications for themselves and their families. They intend to look out for themselves first and expect others to do likewise.

Social harmony, with an easy tolerance of the dissident and the different, also pervades the student environment. Conformists themselves, the American students do not expect others to conform to the socially accepted standard. They are, for the most part, ready to live in a mobile society without racial, ethnic, or income barriers. But they do not intend to crusade for nondiscrimination, merely to accept it as it comes.

Altho most students value the traditional code of moral virtues, they are not inclined to censure those who choose to depart from it. Nor do they feel personally bound to unvarying conformity to the code, especially when a lapse is socially sanctioned. For instance, systematic academic cheating is the custom at many major institutions.

Students normally express a need for religion and often attend church on Sundays, but their religion does not carry over into the secular world. The majority appear to believe that God's place is in church or home, not in business or community.

American students are also only dutifully responsive toward government. They expect to obey its laws and pay its taxes — without complaint but without enthusiasm. Except for voting, however, they are politically irresponsible and politically illiterate.

They have contradictory attitudes toward international affairs. They predict another major war within a dozen years, yet indicate that during the immediate future they expect to give little personal attention to international problems.

Students by and large set great stock by college in general and their own college in particular. Only a minority, however, seem to value their college education for its intellectual contribution or for its nurturing of personal character. Vocational preparation and skill and experience in social "adjustment" head the rewards which students expect from college.

The available data indicate that the profile just given may broadly characterize 75 or 80% of the students. To the remainder, some or most of the generalizations are not applicable. Also, on some issues, such as how much government the country needs, students have no common mind. But the dominant impression is of a nation-wide norm of values pervading the campus.

2. *The main effect of higher education upon student values is to bring about general acceptance of a body of standards and attitudes characteristic of college-bred men and women in America.*

There tends to be more homogeneity and greater consistency of values among college seniors than among freshmen, indicating that the senior has ironed out serious conflicts of values or at least achieved a workable compromise. Thruout college, changes are rarely drastic or sudden. Such changes as do occur tend to emerge on the periphery of the student's character rather than to affect his core of values.

The values of college graduates do differ in some ways from the rest of society. They are more concerned with status, achievement, and prestige. As a whole, they tend to be more self-important, more conservative, more tolerant, and less superstitious and prejudiced than those without college.

It seems reasonable to credit these differences to college, partly to its positive influence in bringing students' outlook into line with a "standard," partly to a subtle selective process which tends to eliminate those not sufficiently adaptive to acquire the value-patterns of the college graduate.

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* A detailed inventory and analysis of this material is available in a report prepared by Dr. Jacob for the Edward W. Hazen Foundation: *Changing Values in College.* Harper. 1957.

But to call this process a liberalization of student values is to use a misnomer. The impact of college rather is to socialize the individual, to refine or shape up his values so that he can fit into his society more congenially.

3. *For the most part, students' values do not vary greatly whether they have pursued a conventional liberal-arts program, an integrated general-education curriculum, or a professional-vocational option.*

The more liberally educated students may take a somewhat more active interest in community responsibilities and keep better informed about public affairs. But the distinction is not striking, and it does not occur consistently. It does not justify the conclusion that a student acquires a greater maturity of judgment on issues of social policy or a more sensitive regard for human values because he has had more liberal education.

There is also no solid evidence of a delayed reaction. The college alumnus exhibits no unusual trademark identifying his undergraduate curriculum.

The same negative conclusion applies to the general effect of social-science courses. Altho many students testify that such courses have increased their understanding of world affairs or interest in politics, the values actually expressed by social-science students — either verbally or in action — are little different from those of others. There is little evidence, for instance, that actual participation in public life has increased as a result of students' taking social science.

4. *Quality of teaching has little effect upon the value-outcomes of students' general education.*

Students have demonstrated an uncanny capacity to evaluate the performance of instructors according to objective criteria. Yet, by and large, the impact of the teacher they consider good is indistinguishable from that of the poor one — at least in terms of his influence upon the students' values.

Some teachers, however, do exert a profound influence on *some* students, even to the point of causing particular individuals to adopt new and usually more socially responsible vocational goals. It is perhaps significant that faculty members having this power are likely to be those whose own value-commitments are openly expressed and who are outgoing and warm in their student relationships.

5. *The method of instruction seems to have only a minor influence on students' value judgments.*

Under special circumstances, "student-centered" teaching reportedly has resulted in a more satisfactory student adjustment and a more congenial learning situation. But the weight of evidence gives little indication that different teaching methods — say the lecture system versus recitation, conference, discussion, or tutorial methods — greatly alter students' beliefs or behavior.

However, individual students are often deeply affected by participation in experiences which vividly confront them with value issues, and possibly demand decisions on their part whose consequences they can witness.

But the practical difficulties of working such activities into the educational process are very great, especially in the general part of the curriculum in which large numbers of students are involved. For the essence of a potent laboratory practice in citizenship, a creative work camp, a meaningful experiment in international living, a stimulating work-study curriculum, or even a well conceived field study is this: Each student personally engages in the action.

Vicarious experience does not deliver the same punch, even tho role-playing techniques in the classroom and the analysis of challenging case studies and problem situations do arouse more interest.

6. *Similar as the patterns of student values appear on a mass view, the intellectual, cultural, or moral climate of some institutions stands out as having a peculiar potency.*

The response of students to education within these institutions is strikingly different from the national pattern.

Such colleges and universities do not fit any institutional type. However, they seem to have in common a high level of expectancy of their students. *What* is expected is not the same.

For instance, the institution may primarily stress intellectual initiative, profound respect for the worth of work, world-mindedness, or a dedication to humanitarian service. But everyone is conscious of the mission to which the institution stands dedicated, tho this is not necessarily loudly trumpeted at every convocation, nor elaborated in the college or university bulletin.

In these colleges, students seem drawn to live up to the college standard, even if it means a wrench from their previous ways of thought.

With a distinctive quality of this kind, an institution evokes a deep loyalty from students, alumni, and staff. A community of values is created which persists long after graduation and often influences the choice of college by the next generation.

7. *Recent research has identified certain personality characteristics of students which filter their educational experiences.*

Some students have a set of mind so rigid, an outlook on human relations so stereotyped, and a reliance on authority so compulsive, that they are incapable of understanding, much less accepting, new ideas. Such students quail in the presence of conflict and uncertainty. They crave "right answers," recoil from creative discussion.

Under most conditions of general education, where content and teaching method have been more or less standardized to suit the average student, the personalities just described become dead wood. A few institutions, however, are exploring special approaches to general education for this type of student, with promising results.

These students rarely achieve the autonomy of those whose personality is freer to start with. But they have shown striking gains in critical thinking and developed more responsible and sensitive social values when their general education in social science, for instance, has been tailored to their particular needs. Because the number of students with such personality characteristics is large and growing, this type of experimentation seems unusually important.

The points presented here imply that no specific curricular pattern of liberal education, no pedigree of instructor, and no wizardry of instructional method should be patented for its impact on students' values. Indeed, the impact of American higher education as a whole upon the value patterns of college youth as a whole seems negligible.

The values of some students do change in college. But even with these, the impetus to change does not come primarily from the formal educational process. It comes from the distinctive climate of a few institutions, the individual and personal magnetism of a sensitive teacher with strong values, or the value-laden personal experiences which students occasionally undergo during college.

In short, college can contribute to the growth of a student's values only when it penetrates the core of his life and confronts him with fresh and often disturbing implications, which are different from those which he and his society have taken for granted. This can hardly occur as a by-product of a curricular assembly line. It requires a highly personal relationship between the college community and the individual student — a relationship that is warm and considerate, but at the same time mutually aggravating.

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The Psychology of Toleration

J. C. FLUGEL

After describing a common-sense view of the notion of toleration, Dr. Flugel, a British psychologist, deals with some psychological investigations made in the United States which were designed to reveal the nature of tolerance as a trait. He emphasizes personal attitudes as expressions of basic human needs, and cites the evidence for the development of these patterns in one's childhood training. The lack of ego threats, the resulting inner security; and the ability to be critical without being hostile are the ingredients of toleration. Dr. Flugel points out some socially undesirable consequences of intolerance and suggests the practical contributions of more desirable patterns of need-satisfaction. Notice the similarity between Flugel's description of dichotomisation and Jacob's student who craves "right answers" (selection 38).

The late Dr. Flugel was well known for his research and writing in England and the United States. He was lecturer in psychology at University College London. This selection is a copy of a radio talk presented on the BBC Third Programme and published in *The Listener* of September 16, 1954 (pp. 441, 445). It is reprinted by permission of the publisher and Mrs. Flugel.

When people think about tolerance or toleration, it is most often with religious, racial, political, or moral questions in mind. I would like to invite you to consider this subject from a slightly different angle — that of psychology. What is tolerance considered as a state of mind? I think it would be generally accepted that in the first place tolerance lies somewhere between love and approval on the one hand, hate and disapproval on the other. We do not have to tolerate a person we love, or a cause to which we are devoted; but we may have to exercise tolerance towards the presence or behaviour of a person who irritates us, or in listening to the advocacy of a cause which we think wrong. Tolerance is indeed in some ways nearer to hate than to love. But it implies that the natural and immediate reaction to hate is held in check. What is our immediate reaction to a person we dislike? It is to say: 'Clear out!' while to someone advocating a cause we disapprove we should say 'Shut up!'

HEARING THE OTHER SIDE

But in the attitude of tolerance such reactions are, as the psychologist would say, inhibited. This means, in effect, that we are willing to suspend judgement for a while and, in the words of St. Augustine, 'hear the other side.' And if we are willing to listen to what the other fellow has to say, this implies that, after all, there may be something in it; what he says may not be mere wickedness or nonsense, and we ourselves may not have a monopoly of what is right and true.

This attitude is a very important one in science. No scientist pretends that he possesses 'the whole truth and nothing but the truth'; there is always something to be added to his knowledge or modified in his beliefs. The bigot, on the other hand, feels that he alone is right and that anyone who ventures to differ from him is wallowing in heresy and error — error so pernicious that it obviously needs to be suppressed. Bigotry thus inevitably leads to intolerance, while open-mindedness is intimately associated with toleration — and with liberty. As an American judge once put it, 'The spirit of liberty is the spirit that is not too sure that it is right.' Intolerance, on the other hand, is closely connected with prejudice, prejudice being a judgement formed without due knowledge and consideration of the facts.

I have mentioned prejudice because it is a subject which has much engaged the attention of psychologists in recent years (especially in America) and they have carried out a number of investigations, the results of which cast a good deal of light upon the nature and mental make-up of those who display tolerance or intolerance. A consideration of some of these studies will take us a little beyond the superficial and more or less common-sense approach with which I have been dealing so far.

Most of these investigations had their origin in the study of what psychologists have come to call 'attitudes,' especially the attitudes of the members of one race or nation towards those of another. For instance the subjects of an experiment were presented with a list of attributes, such as 'industrious,' 'artistic,' 'religious,' 'lazy,' 'cruel,' etc., and were asked to say which of these attributes were applicable to a list of certain races or nations. In other cases, the races or nations had to be put in order of personal preference, or the subjects had to say how far they would allow members of these races to various degrees of social intimacy, to visit their own country, to reside in it, to become members of their own professions, to join their own clubs or to intermarry with their own near relatives. These studies revealed the existence of so-called 'stereotypes,' more or less rigid, exaggerated, and emotionally toned beliefs, for the most part based on very insufficient knowledge — sometimes indeed on no knowledge at all; in fact, in one investigation catch questions were included on non-existent races, such as 'Daneirians,' 'Pyrenians' and 'Wallonians,' and many subjects gaily attributed good or bad qualities to these, based on nothing better than dim and confused associations. These 'stereotypes,' in fact, were for the most part just striking examples of racial and national prejudice.

In some more recent investigations psychologists have picked out those who display unusually great or unusually little prejudice of this sort, and have studied more intensively the mental background of the two sorts of people. Starting with childhood, it was found that the prejudiced and intolerant had grown up in a home atmosphere of greater harshness, discipline, and fear — one in which authority played a more important role than love. On the other hand, those who in later life showed less prejudice and greater tolerance felt that fundamentally they were accepted, and that if they were punished it was some particular act rather than they themselves as persons that had met with disapproval. They thus had less deep irrational anxiety and a greater sense of security — and this security indeed seems to emerge as the first basic factor in the tolerant attitude, whether in the individual or in social groups.

The tolerant and the intolerant individuals showed a further interesting difference, one which reveals itself in a contrast between two levels of the mind. At a more superficial level the tolerant people were ready to criticize their parents, though at a deeper level they still loved and respected them, in spite of the fact that they could recognise their failings. The intolerant on the other hand would stoutly maintain that they liked their parents, and were loath to say anything against them, though deeper psychological probing showed the presence of jealousy, suspicion, and hostility at more unconscious levels. All children both love and hate their parents; they all display what psychologists call 'ambivalence' towards them. But in the tolerant the conflict was more at the surface, whereas in the intolerant the hostility had been repressed.

It is interesting to note that much the same kind of difference was brought out in other experiments in which groups of young people were deliberately conducted on authoritarian or democratic lines respectively. The members of the democratic groups, who participated in the government, could more openly criticise their leaders (though without necessarily disrespecting them), but the members of the authoritarian groups, who had simply to obey their leaders' orders, had more suppressed aggression — aggression which tended, moreover, to find an outlet in hostility towards others, especially towards other groups. It is as though aggression will out, must find expression somewhere; and it may find what seems to be a relatively harmless outlet at a superficial level within our own group, or it may find a more harmful and dangerous one towards innocent victims, strangers or external groups.

If we allow ourselves to generalise from these experiments, we can say that democratic government, whether in the home or in the larger group, is associated with tolerance, whereas authoritarianism breeds suppressed aggression and intolerance. The political implications of this are obvious enough, though we must be careful in applying conclusions drawn from small and relatively simple groups to the much more complicated conditions operative in great nations.

IMPORTANCE OF INNER SECURITY

As far as our present knowledge goes, then, the basic conditions of toleration are to be found in these two interconnected factors: a certain fundamental inner security on the one hand, and on the other an ability to express some degree of criticism and aggression at a relatively superficial level — often towards people whom at bottom we still love and respect. But several other aspects of this fundamental condition have been made out — aspects which are all, to some extent, interrelated with one another and with what I have called the two basic factors.

In the first place, we may notice among the intolerant a greater tendency towards what the psychoanalysts call 'splitting', or what one eminent American psychologist prefers to call by the more erudite name of 'dichotomisation'. This means that the good and bad aspects of the parent or other authoritarian figure are, as it were, separated and attributed to different persons. This has long been recognised as one of the means which the mind employs for getting rid of the uncomfortable tension caused by the ambivalent attitude, the coexistence of love and hate towards the same person. In some degree it is a common human tendency, as exemplified in the contrast between *le bon Dieu* and the Devil, or, as in certain fairy stories, between the wicked stepmother and the fairy godmother. When generalized, this splitting process tends to make one see everything in terms of white or black. It has been found, for instance, that the intolerant type of person is likely to disagree with such propositions as are contained in the doggerel rhyme:

There is so much good in the worst of us,
So much bad in the best of us,
That it scarcely behoves any of us
To talk about the rest of us.

The tendency to split the good and bad in this way, helpful as it may be as a refuge from intolerable tensions, inevitably does violence to psychological fact; the rhyme I have just quoted comes much nearer to the facts of human life than does the whitewashing and denigrating of the 'splitter'. It is therefore not surprising that the tolerant are better psychologists than the intolerant. This applies both to self-knowledge and to the understanding of others. Several researches show that the tolerant have a greater knowledge of their own deficiencies and limitations, can tolerate their own shortcomings as well as those of other people; while at the same time they can sum up another's character in a short interview more accurately than the intolerant can do.

They may, however, sometimes show less tolerance to themselves than they do to others; in fact the danger which threatens those who are externally tolerant is that they may judge themselves too harshly and fall victims to feelings of guilt and inferiority; whereas the corresponding danger of the externally intolerant is that they do not consciously admit their own faults, but only too often attribute them to others. This process of projection, as it is called, the inclination to blame others for what are at bottom our own deficiencies or faults, is responsible for the tendency to find scapegoats — a sinister tendency — which has played a long and terrible role in human history.

Another characteristic of the intolerant is that they tend to lean more heavily on authority. This is true both of the more intangible values of opinion and convention, and of actual institutions in which authority is embodied, such as the state with its legal sanctions. The tolerant, though they may by no means be less moral, are more flexible in their morality; they are more ready to exercise their own judgement as to what is right or wrong in any particular instance, whereas the intolerant are apt to lay more stress on the letter of the law. The tolerant are more capable of laughing at themselves and at the things and persons they love; and it appears that they can do this because of their greater sense of inner security, which is not seriously threatened even if they do admit that they themselves, their parents, their country, and their customs may in certain ways be a little ridiculous. They do not need the law of *lèse majesté* or the inner attitude which corresponds to it.

This sense of security can, of course, apply to nations and institutions as well as individuals; and in the light of this we can appreciate an incident which was credibly reported to me in my youth. A foreigner, an ardent admirer of Britain, who had recently come to this country, was horrified to hear a tub orator at a street corner shouting 'Down with the Queen, down with the Royal Family!' He hurried off to fetch a policeman, who, when he saw the speaker, said 'Why, bless your soul! Old Bill Bloggs has talked here of a Saturday night last twenty years or more!' Bill Bloggs had, in fact, become an institution, and Queen Victoria at the zenith of British power was felt by all to be so securely seated on her throne that Bloggs could be safely left to express his anti-royalist sentiments to all who cared to listen to him.

I have tried to put before you a few of the findings of recent psychological research regarding this question of tolerance. If they seem to you almost suspiciously favourable to what we might call the democratic way of life, I would ask you to bear in mind three things. A good many of the experiments I have described are based on the selection of the top and bottom twenty-five per cent. as regards tolerance, and they give too clear-cut a picture when we try to apply it to any random sample of the population as a whole; at least fifty per cent. of us fall in between the extremes — we are, as it were, lukewarm both in our tolerance and in our intolerance. Secondly, I have said nothing, or next to nothing, about the possible dangers of toleration, which in the past history of humanity have sometimes placed the tolerant at the mercy of their more bigoted and fanatical neighbours. In the third place, psychology is a relatively new science, and too much faith must not be placed on the results from methods which are still often crude as compared with those at the disposal of the physical sciences.

Nevertheless, the mere adoption of the psychological point of view to social problems, apart from the results obtained, can, I believe, be of great significance in dealing with the anxiety, suspicion, and aggression which create so much havoc in our human relations. When those who hold strong views start to think in psychological terms, they begin to acquire both some interest in, and some respect for, what goes on in their own minds and in those of other people, and this itself is a first step in diminishing intolerance.

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Theme and Variations

STAFF OF *TIME* MAGAZINE

This "outline of psychoanalysis" presents the main tenets of the movement as proposed by Freud and with the variations advocated by more recent leaders of the psychoanalytic school. Unquestionably no other group has had as much influence on the patterning of psychologists' thinking about motivational processes as have these seven persons. Nevertheless, a large number of psychologists who are more experimentally oriented are critical of these mentalistic formulations as being unproven, as will be seen in the next selection. The most significant of these criticisms concerns the fundamental psychoanalytic assumption of a mental energy being ascribed and treated as *thingness* — the psyche. Thus, the difficulty is not only that so many beliefs are unproven, but that they are by definition untestable. For some, then, psychoanalysis falls outside the scientific enterprise, yet the insights provided — especially the need to examine early experience — have made a deep impression.

On the occasion of the centennial of Freud's birth, the staff of *Time* magazine prepared a feature story on his life and teachings, of which this selection is a part. It appeared on page 71 of the issue of April 23, 1956, and is reprinted by courtesy of *Time*. Copyright, Time, Inc., 1956.

If self-analysis made Freud a relatively adjusted man, it never blunted the sharpness of his search for understanding. He was too restless an explorer to remain content with his theories, worked until his death on amendments and additions. He was far less tolerant toward others' discontent with his theories, bitterly opposed some followers' deviations, but might well have accepted others that have developed since. Some rudiments of the Freudian main theme and principal variations:

Sigmund Freud held that the nature of man is essentially biological; man is born with certain instinctual drives. Most notable: the drive toward self-gratification. Basic mental energy, or *libido*, is equated with sexual energy by making the word "sex" stand for all pleasure.

Infant's first search for gratification is limited to release of hunger tension — *oral* phase. If there is no nipple handy, he puts thumb in mouth. Next comes satisfaction from defecation — *anal* phase. Third, pleasure from sensation in sexual parts — *phallic* phase. (Association of sexual gratification with reproduction — *genital* phase — does not come until sexual maturity.) Beginning about age two, the child's emotional attachment to mother leads to wishes to displace father — *Oedipal feelings* (the older, more rigid concept of an Oedipus complex is now frowned upon.)

The psyche is divided horizontally into *conscious* and *unconscious*, vertically into *id*, *ego* and *superego*. Gradually the child's unconscious fills more or less deliberately with things forgotten (*suppressed*) because they are unpleasant, and, more importantly, with emotions and drives which are too painful ever to be tolerated in consciousness (*repressed*).

The *id*, entirely unconscious, most primitive part of the mind, is concerned only with gratification of drives. The *ego*, almost entirely conscious, develops from experience and reason, deals with perception of the environment, tries to go about governing id. *Superego*, largely unconscious, sits as judge, decides whether or not ego may permit id the gratification it seeks; it is conscience, made up of attitudes absorbed unwittingly in childhood and (to a much less extent) of attitudes consciously learned or adopted later.

Neurosis, to Freud, results from unsuccessful attempt by the personality to achieve harmony among id, ego and superego, and this failure in turn results from arrest of development at an *immature* stage. Commonest cause of emotional disharmony: failure to resolve *Oedipal feelings*. Example: many girls who profess to seek marriage actually avoid it because the prospect activates the threat of unacceptable emotions which are *fixated* to their fathers.

Among the *mechanisms* used to deal with conflicts: *projection* involves denial of an unacceptable element in the self and projecting it onto others, e.g., man who bangs desk and shouts: "Who's excited? You're excited, not me!" *Reaction formation* covers conversion of unacceptable hostility into cloying solicitousness, seen in many do-gooders and some overprotective mothers who unconsciously *reject* their children.

Another way of using libidinal energy: *sublimation* into constructive and creative work or play.

To *resolve* neuroses, patient on couch tells in *free association* all that comes into his mind, especially about early *trauma* (shock). Since infancy and much of childhood are consciously "forgotten," these experiences must be recaptured with the help of the language of dreams — perhaps the most important single tool of analysis. There is no absolute symbolism (snakes may be phallic to one dreamer but to another merely reminiscent of a trip to the zoo), hence no universal key to the meaning of dreams. Analysis is complete when the patient has developed social responsibility, having dredged up all pertinent childhood traumas, recognized his unconscious Oedipal and other socially unacceptable impulses, and learned at a deep emotional level rather than a superficial intellectual level to live with such id-bits.

ALFRED ADLER (1870–1937) developed "individual psychology," which denies the overriding importance of infantile sexuality, argues that sexual maladjustments are a symptom, not a cause of neurosis. Adler gave *inferiority complex* to the language, said infants have *inferiority feelings* because they are small, helpless. Lack of parental tenderness, neglect or ridicule may make these feelings neurotic. Natural tendency is to seek *compensation* by becoming superior, hence open struggle for naked power. *Power drives* are often neurotic because directed to impractical goals. Emphasized ego over id.

CARL GUSTAV JUNG of Zurich holds that primal *libido*, or *life force*, is composed of both sexual and nonsexual energy, accepts an individual unconscious similar to Freud's but sees also a *collective unconscious* containing man's "racial memories." Within this are emotional stereotypes (*archetypes*) common to all races of man, e.g., the Jovian figure of the "old, wise man," the earth-mother. In Jungian "analytical psychology," the analyst participates more actively than in Freudian analysis. Jung aims especially at people over 40, largely because he believes they most feel the need of a religious outlook, which he encourages.

OTTO RANK (1884–1939) went Freud one better, held that Oedipal feelings came too late to be decisive. Real trouble, said he, was *birth trauma* — the shock of having to leave the warm security of the womb for the harsh reality of separate life. Anxiety caused by this experience formed sort of reservoir which should seep away gradually during maturation. If it persisted, then neurosis set in. Rank hoped to shorten analysis by going back to birth trauma, ignoring most of childhood.

KAREN HORNEY (1885–1952) applied the thinking of anthropologists and sociologists to psychoanalysis; gave great weight to cultural factors in neurosis. Rejected Freud's biological orientation, emphasized importance of *present life situation*. Modified Adler's concept of neurotic goals, adding that these contain their own sources of anxiety. Thus in coping with one difficulty, patient may set up neurotic defenses which bring on new difficulties, and so on. Widely remembered for her unfortunately titled book, *Self-Analysis* (1942), which is no do-it-yourself kit for cracks in the psyche.

HARRY STACK SULLIVAN (1892–1949) held that the human individual is the product of *interpersonal relations*, based an entire analytic theory on this concept. Pattern of child's earliest nonsexual relationships with significant figures largely (but not rigidly) determines the pattern of all later *interpersonal integration*. Man's aims are seen as pursuit of satisfaction (biological) and pursuit of security (cultural). If society denies satisfaction in sexual sphere, neurosis may result, but according to Sullivanians (a numerically small but influential school in U.S.), it comes far more often from frustration, for whatever reason, in cultural sphere.

Erich Fromm of Manhattan and Mexico City denies that satisfaction of instinctual drives is focal problem, points out that man has fewer inherited behavior patterns than any other creature. In feudal times, he argues, the stratified, crystallized society wherein every individual knew his place gave security. Renaissance and mercantilism brought *freedom from* antlike existence but conferred (except on a privileged few) no *freedom to* work toward individual self-fulfillment. Thus neurosis today results mainly from frustrations which present trend of society threatens to intensify.

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Some Hypotheses of Psycho-Analysis

B. A. FARRELL

Psychoanalytic theory is rich with hypotheses concerning human motivation and the devious behaviors indulged in to satisfy needs. Psychoanalysts themselves are prone to be content with clinical evidence as sufficient support for these hypotheses, but a science of psychology requires more positive evidence in the form of experimentation. The author of this selection reviews some of the efforts in the program of research. Notice that he recognizes different levels of support when he remarks that certain experimental results are "not inconsistent" with psychoanalytic theory. This is a desirable step toward understanding human motivations, and may well lead to more definitive kinds of experiments. Thus behavioral science makes progress. The reader should recall from an earlier selection that the scientist's treatment of an hypothesis is to subject it to every possible test, including efforts to reject it.

Dr. Farrell is Wilde Reader in Mental Philosophy at Oxford University. This selection was one of a series presented on the BBC Third Programme and is Chapter IV of *Experimental Psychology*, published by Basil Blackwell in 1955. It is reprinted by permission of the publisher and the author, who was also editor of the book.

It is commonly said or believed that the only branch of psychology which has achieved anything worth while is that of psycho-analysis. We have even been told recently that Freud is the one psychologist of genius to emerge to date. Consequently, people are apt to be a little surprised and puzzled — even people who consider themselves well educated — when they discover that many psychologists tend to look with scepticism at the conclusions of psycho-analysis and to regard them as suggestive but generally unproven.

Fortunately it is easy to discern the reason for this state of affairs. Psycho-analytic work has thrown up a large number of hypotheses about the development of children, the formation of character, the nature of neurotic disturbances, distortions of sexual functioning, and so forth. These hypotheses are often surprising and striking in character, and the claims they make are large. Consequently these hypotheses are very important indeed — *if* they are true.

Well, are they true? When we ask psycho-analysts for the supporting evidence, we find that this comes largely from the behaviour of adults who have been psycho-analyzed. Thus the kernel of the evidence for, say, the hypothesis about castration anxiety is to be found in the alleged fact that, when an adult male works through his parental relations in analysis, he produces typical reports of castration anxieties he felt as a boy — reports which he now accepts as correct. But it is a commonplace that this type of evidence, namely clinical evidence, does not provide strong support for the hypotheses of psycho-analysis. This is so for various reasons. Not all adult males who undergo analysis produce reports of castration anxieties and fit into the Freudian picture of personal development. Some adults appear to conform more under analysis to the picture of development which Adler has given us, or to fit in better with Jung's description of personality. Moreover, the fact that a man in analysis may recall boyish fears of, say, castration, is not sufficient to establish that he really had them as a boy. For it is well known — and Freud himself was among the first to emphasize this fact — that when we remember the past we are apt to distort and reconstruct it to a surprising degree; and it is not unplausible in most cases to hold that these allegedly boyish fears may be only adult fantasies. Furthermore, the fairly frequent occurrence and uniformity of reports of castration fears may only reveal a fairly *systematic* distortion of childish anxieties, connected with the fact that in analysis the adult is playing the role of a child with adult-like wishes and fears. And the conviction with which he now recalls these allegedly boyish fears — far from lending support to the hypothesis of castration anxiety — may be quite misleading. For this conviction may spring largely from the relief which the patient feels when he produces and accepts these reports in adult analysis, and it may be no criterion of their validity. In addition, the fact that these reports of castration fears may help to improve or cure an adult's condition carries little evidential weight; and it counts against the hypothesis that it is difficult to detect these castration fears by the direct observation of children.

I have said that many psychologists are sceptical about the hypotheses of psycho-analysis. What I have just been trying to do is not to refute these hypotheses, but to show why clinical evidence by itself is insufficient to establish them and so to point out why psychologists are sceptical about them. But because these hypotheses are so important, if true, a psychologist wants to know whether there is any other evidence to support or rebut them. He becomes interested in devising ways and means of trying to discover just how much there is to be said for them. The chief trouble with clinical situations is clearly the complexity of the factors at work and our inability to control them. The obvious way, therefore, to begin a non-clinical investigation into the hypotheses of psycho-analysis is to examine much simpler situations, and to use the techniques of experimental psychology (in a wide sense) to isolate and, if possible, to control the factors at work. Over the last twenty or more years, a number of psychologists have conducted investigations of this sort. The best way, perhaps, to show the sort of thing that has been attempted and discovered is to describe some representative examples of these studies.

Consider one of Levy's investigations into sucking. Freud suggested that infants get pleasure just from sucking at the breast, and that thumb-sucking is determined by a search for this pleasure, of which they have been deprived. Levy took a litter of six puppies at birth, and divided them into three pairs. The first pair was fed by a bottle with a small nipple-hole and after each meal was allowed to suck till satisfied on a nipple-covered finger. These were the long feeders. The second pair was fed by a bottle with a large nipple-hole and was not given a finger to suck afterwards. The third pair was left with the bitch. The experiment lasted twenty days, the long feeders averaging a little over an hour's sucking every day, the short feeders only twenty minutes. The upshot was as follows. The short feeders chewed and sucked at each other's bodies between meals and were very responsive to the nipple-covered finger when offered between meals; the long feeders did no body-sucking and only responded to the nipple finger just before meals; the breast feeders did no body-sucking and never responded to the finger. This result suggests that the puppies did indulge in pleasure-sucking, and that Freud may be right in supposing human infants do the same and suck their thumbs as a result of deprivation. There is other psychological work on human infants which, in general, points to the same conclusion; but I picked on this work of Levy's as a neat example to show how experimental work can invade a complex field.

Consider, next, the hypothesis of the so-called 'oral character.' This hypothesis supposes that people are distinguishable on a continuum into two types, the self-assured optimists at the one end and the insecure pessimists at the other; and it asserts that a person's position on this continuum is determined by the gratification or frustration he (or she) experienced at the breast. Frieda Goldman (of London), using questionnaires and factor analysis, discovered that her subjects were distributed on this continuum in the way that psycho-analysis supposes them to be. She then found out from the mothers of the subjects whether the child had been breast-fed, or bottle-fed from the start, and if breast-fed when it was taken off the breast. The position of subjects on the optimistic-pessimistic continuum was then correlated with early or late weaning. It was found that there was a small, but significant, correlation between early weaning and pessimism, unsociability and so on, on the one hand, and between late weaning and optimism, sociability, generous inclinations and so on, on the other. This small but significant correlation suggests that the hypothesis of psychoanalysis has drawn our attention to one of the factors that may be at work in the development of the so-called oral character. Of course, all that Dr. Goldman has done here — as she points out herself — is to establish a correlation between weaning time and character; she has not shown that frustration or gratification at the breast *determines* the development of character. Yet this is what the analytic hypothesis about oral character maintains. At best an analyst could claim that Dr. Goldman's work is not inconsistent with his hypothesis at this point.

Now psycho-analysts have tended to object to some psychological investigations on the ground that psychologists have not been investigating the hypotheses of psycho-analysis at all, but only some thin, watered-down versions of them. It is possible to reply to this objection by pointing out that it is a misunderstanding of the logic of scientific method. Some psychologists, however, have tried to meet the analysts here by devising methods of investigation that *would* bring them nearer to the complex statements of psycho-analytic theory. Thus, Blum (in California) has devised what is called a 'projective' method or test to study the analytic theory of psycho-sexual development. His test consists of twelve cartoon drawings, devised for an audience accustomed to comic strips, which depict the adventures of a dog Blacky, along with Mamma, Papa, and Tippy, a sibling. The cartoons are intended to depict stages of psycho-sexual development, or types of relationship to things and persons in that development — as suggested by psycho-analytic theory. Thus, the cartoon depicting Oral Sadism shows Blacky angrily chewing a dog-collar with 'Mama' clearly printed on it. The cartoon to bring out castration anxiety shows Tippy in the background, blindfolded, with his (or her) tail stretched out over a block of wood and a large knife about to descend and cut it off; and in the foreground Blacky looks on with his back to the viewer. The chief tasks given to the subjects of the tests are to write a short story quickly and to answer some questions on each cartoon. Blum found, from the significant data which he collected, that the test findings agreed with twenty-two out of the twenty-three hypotheses of psycho-analytic theory he investigated on psycho-sexual development. Thus, for example, the test showed that in his sample of subjects identification normally takes place with the parent of the same sex, but that males identify themselves more decisively with their fathers than do females with their mothers. It showed for example, also, that males whose oral development had been disturbed are more likely to possess castration fears. The sole point of disagreement with psycho-analytic theory was the finding that females tend to have a conscience derived from the mother rather than the father.

Of course, this result may sound much more impressive than it really is. For Blum supposes that his cartoons do really tap a person's oral sadism, his oedipal attitudes, and so forth. It is quite possible, however, to describe the effect of the cartoons on a person in a way which is not psycho-analytic at all — an objection which Blum implicitly accepts and which throws doubt on the interpretation of his results.

A large part of psycho-analytic theory is concerned with the nature of conflict and with modes of adjustment like repression, regression and displacement, which analysts have called 'The Mechanisms of Defence.' When psychologists looked into this field, they did so, in part, by investigating organisms which are simpler than human beings and whose history could be known and controlled. Generally speaking, their results, while far from conclusive, have gone to support the psycho-analytic hypotheses in this field. Other psychologists have tried to discover the conditions sufficient to produce conflict in animals and the effectiveness of different modes of treatment. Masserman's work in Chicago on cats provides an interesting single example of studies of this sort. Masserman showed that neurotic conflict in cats bore an uncanny similarity to such conflict in humans. Like humans, the cats exhibited phobias, compulsions, regressive behaviour, masochistic aberrations, and the like. Again there was the same uncanny parallel when the cats were given psychotherapy — some cat patients even showing the analogue of 'transference'; and Masserman found that the effective modes of therapy were those requiring *spontaneous* readaptation on the part of the animal. There is one thing, I think, which this work on animals has achieved. It has helped to make clear that further understanding of the nature of human conflict and the mechanisms of defence will probably develop in the general direction which the psychoanalysts have pointed out.

But psycho-analysis is concerned with humans, not animals. As my last example of an experimental study, I shall take the work of Keet (of Johannesburg) on the experimental production and cure of, what can be called, a minute conflict or 'micro-neurosis' in humans. Keet first administered Jung's word association test and so discovered a word which disturbed the subject, as well as two other words associated with it. In this way he obtained for each subject a family of three words, for example, 'nasty' (the disturbing word), 'messy' and 'mean.' The subject was now required to learn a list of six words, of which the disturbing word was one. Next, he was required to learn a *new* list of six other words. Finally, he was asked to recall the *first* list he had learnt. Twenty-five out of his thirty subjects were not able to recall the word in this first list which they had each found initially disturbing. Here now is a minute conflict offering the opportunity for psycho-therapy, the success of which can be determined in part by the recall of the forgotten word. The best way to appreciate the nature of the conflict and how Keet treated it is to listen to part of the verbatim report of a therapeutic interview.

The subject here was a young married woman, for whom the three words were 'nasty,' 'messy' and 'mean.' When asked to recall the first set of six words, she could not recall the word which had disturbed her, namely 'nasty.' During the first part of the interview Keet offered no interpretations of her difficulty, and she struggled vainly to remember the word. The interview then continued in the following way:

SUBJECT: . . . You think me very stupid, don't you? (*She laughs.*) I suppose I am really. I should be able to recall the word. It is most exasperating. I feel quite angry with you, sitting there so smug and self-satisfied. Could you do it? I mean have you tried it on yourself? (*She laughs when she sees the experimenter smiling.*) Oh, is the word 'green'? That does not seem to ring quite true. I am sure it is not 'green'. I went overseas once and got very seasick . . . turned green . . . (A *pause.*)

(*The experimenter now makes an interpretative remark.*): 'Perhaps there is something about the word itself,' he said. 'You may have had some experience, or something like that . . .'

SUBJECT: I often used to feel sick when I got angry. I did a moment ago. Just the faintest feeling in my stomach when I felt a bit angry with you. I was very seasick when I went to Europe. Turned very pasty and green . . . I was all alone — the youngest in the swimming team. Pasty. (A *pause*).

EXPERIMENTER: You say you feel a little nauseated when you are angry.

SUBJECT: Yes, whenever my sister and I quarrelled and I got very angry, I was nauseated. Once I even got sick and vomited. I did not like the mess. This is not so bad nowadays. Only when I try to hold my irritation back, then I get it. I always thought my sister was stronger than I am. We used to have real fights sometimes. (*Laughs.*) I don't feel so confused any more. Do you think the blank, blank word . . . (*She laughs*) I can't remember it yet. Can it have anything to do with my quarrelling with my sister? My father liked her very much more than he did me. (*Pause.*)

EXPERIMENTER: Maybe. And perhaps it's connected with some more recent experience.

SUBJECT: You mean with my husband . . . Oh, that just slipped out. (*She laughs.*) Now I have said that, I might as well tell you we had a quarrel the other day — a rather bitter one. (*Pause.*) I still think he was very mean. (*Said with some vindictiveness.*) When people get nasty like that I get very angry. I mean nasty. Of course, that's the word. 'Nasty.' Well, I never. How do you like that! Do you really think this has something to do with my quarrel with my husband? It's very funny.

That was part of Keet's report; and the results of the whole experiment are equally striking. You will recall that I pointed out earlier how weak the clinical evidence is on which psycho-analysts rely. It is clear that Keet provides us here with examples of the sort of conflict and cure with which analysts are especially concerned, and in so doing he provides us with clinical evidence which is obviously *stronger,* because obtained in a more controlled way, than that on which the analysts usually rely. For this reason I should like to see his work successfully repeated by others, and developed, if possible, to test specific hypotheses of psycho-analysis about the nature of conflict and its treatment.

Well, what light have the investigations of the psychologists thrown in general on psycho-analytic hypotheses? Not much to date. Their results suggest that part of the analytic story about psycho-sexual development is correct (for example, about erotogenesis), but that other parts of it (for example, the Oedipal story) are weak and possibly false. Their results lend some weight to the analytic hypotheses about the mechanisms of defence, and some support to Freud's theory of dreams. They strongly suggest that the analysts have uncovered some of the essentials of human conflict, though we are still uncertain what these essentials amount to. What the psychologists have not yet done is to extract from their studies of psycho-analytic hypotheses much *new* information about human beings — new information which an intelligent psychiatrist could not have predicted in the first place. On the other hand, the psychologists have shown that the phenomena we are dealing with are even more complex than they had anticipated, and that psycho-analytic theory is even vaguer than they had previously thought. I think they have made the analysts more cautious about their claims, and have even made some of them interested in the experimental attack on the field, which is a very happy development. By their experimental studies, psychologists have succeeded in opening up one route along which we may be able to discover what credence to attach to the theory and practice of psycho-analysis. In doing this they have also revealed that it is possible to develop an experimental psycho-pathology, and thus considerably to extend the application of scientific methods in the field of abnormal behaviour. I think these are important and exciting achievements.

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What's a Nervous Breakdown, Anyhow?

STAFF OF *CHANGING TIMES*

Like most dynamic functions, human motivation patterns sometimes go awry. This article deals with the kind of behavior disturbance popularly known as a "nervous breakdown," which is not a disease of the nerves. It is believed that every person has tolerance limits for stressful demands. Modern civilization, coupled with individual differences in susceptibility, takes a toll of about one of every ten in the United States. Included in this selection are the symptoms (psychological and physiological), nature of susceptibility (note similarities to personalities described in other selections), the victim's behavior, and the desirability of seeking (and wanting) professional assistance.

A "breakdown" is considered as a loss of ability to control the environment for satisfaction of needs, and the critical aspects include a "bottling up" of the expression of thwarted motives, often touched off by a crisis or turning point in one's life.

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Through the mist of superstition and fear that for centuries has surrounded mental disorders, most of us for the first time are beginning to glimpse some of the unmysterious facts about nervous breakdowns. And now, when one out of every ten persons faces the statistical possibility of suffering a breakdown, it is time to lay the old ghosts once and for all.

And facts are at hand to dispel the myths:

Anyone under sufficient strain — the amount and the kind of strain required depending on the individual — can crack. So rule out the old wives' tales about "germ of madness," "tainted blood," "nerves in the family."

Such a crack-up has, in most cases, no relation to mental weakness. It is, rather, evidence of an intelligent mind that has fought the problems of life not too feebly but too strongly.

A nervous breakdown is nature's way of calling time-out. A sort of moratorium in the midst of a battle with overpowering problems, it is one of the most curable ailments known to doctors. So rule out, too, any vague idea that a nervous breakdown ruins its victim for life. People do get well, and what's more, they stay well.

Those facts are basic. To understand them better, you need to know more about the ailment and its victims.

CIVILIZATION, THE MAN-KILLER

There is no such thing as a typical sufferer. All kinds of people in all walks of life can be stricken, given the right kind and amount of strain or shock.

During the war, psychiatrists learned that the number of combat fatigue cases mounted in direct proportion to the number of days in battle. They concluded that any outfit left in the field long enough would suffer 100% casualties.

Most people, however, are not subjected to that kind of mental torture. The strains imposed by ordinary living are, of course, less severe. But a certain type of person is more susceptible to these day-to-day strains than other types, and for that reason scientists have been able to draw a general picture of the person most likely to have a nervous breakdown — not the only kind of person who may have one, remember, but the most likely.

In the first place, this most susceptible person has a high IQ, a strong imagination and a mind adapted to probing into the hidden intricacies of a problem as well as its surface aspects.

He (or just as often, she) is also a perfectionist, either through natural bent or parental training. He goes 100% or nothing. His need for self-esteem is great, and yet the standards that he imposes on himself in order to earn it are impossibly high. He expects a great deal of himself and loses face in his own estimation when he fails to measure up.

Put such a person in a tension-filled situation and see what you get.

If he is in an environment that allows him self-expression, he is inclined to overdo it. He takes on too much — too many responsibilities, too many decisions, too many duties. He fights for perfection at his job and, more than likely, adds extracurricular activities that give him no time for rest.

On the other hand, if he is in a situation that allows him insufficient expression, boredom and a feeling of worthlessness may drive him into a state of mind in which he is easy prey to the rub of irritation.

More important to remember than this general description, however, is that different people react differently to strain. One person may thrive on responsibility and blow up under regimentation. Others cannot make a decision but are perfectly capable of doing what they are told. Some revel in a good fight; a cross word can send others into the jitters.

Also, a current incident can conjure up the ghost of a past worry, injury or fear so that what would be a simple enough occurrence for a person without such memories becomes complicated for another person.

Here is what happens when the nerves are under constant bombardment from big and little strains. Each gathering of nerve resources to face trouble sends a tension-order to various muscle groups. The muscles tense, producing changes in tone and equilibrium, and can only relax through appropriate action.

The nervous person, to relieve tension, may drum on the table or fiddle with a lock of hair, smoke too many cigarets or drink too much coffee, resort to alcohol or eat too much food. Sometimes, of course, he explodes in a quick emotional outburst, but for the most part, being civilized demands that he keep emotions bottled up.

The result is that too many tensions, too tightly corked emotions, build up pressures until they are unbearable. Then along comes what may be called a trigger action, which can be almost any critical situation.

This final blow may be a severe shock, as the loss of a loved one. Such a grief is tough enough for a person not already at the breaking point but becomes unmanageable for someone at the end of his rope. Or the crucial emotional storm may not have a cause in the immediate past but in the near future. In this case, the nervously exhausted person is unable to face the trial to come and attempts to evade it through a collapse of nerves.

Insecure children may have this reaction just before entering a new school. Uncertain and oversheltered girls may have it on the eve of marriage. Young men about to leave college and face economic competition may unconsciously balk at the strain. Businessmen, weary of the task of keeping up with their jobs, may be unable to cope with the problems entailed by a promotion.

The trigger action can be, too, such an unimportant moment of stress that it remains forever unfound. It is, in that case, merely the last straw for overwrought emotions.

Whatever the immediate cause, the result is the breaking down of the powers to withstand and cope with problems, worries, fears, failures and ordinary frustrations — in fact, strains of all kinds. This is a nervous breakdown.

SYMPTOMS AND EFFECTS

It is not easy to determine what is a nervous breakdown and what is not — and indeed the term is subject to loose definition — but there are signs of warning, both before and after the breaking point has been reached.

The first hints may be irritability and disturbed sleep. Grouchiness, blues, chronic depression and overpowering fatigue not relieved by sleep are other danger signals.

There may be these, too: loss of power to concentrate, quick fatigue from even slight mental effort, an inability to make even minor decisions, a distaste for hobbies, entertainment and work that once were enjoyable.

These disagreeable tendencies coupled with a completely self-centered turn of mind may puzzle and disturb members of the sufferer's family, but he himself can neither check them nor worry about them particularly.

He has another problem, namely, a collection of very real and extremely troublesome aches and pains.

Tensions create all sorts of maladies that can't be cured because they lack an organic cause. There may be a fast or irregular heart beat — without heart trouble. Horrible stomach pains — without ulcers. Tightness in the back of the neck and in the shoulders — without neuralgia. And a host of other symptoms.

One of the most curious is a reaction called hyperventilation. This is a chronic, usually harmless but always uncomfortable, result of gulping too much air. A nervous person, entirely unaware of his action, will take deep, sighing breaths as an automatic reaction to stress. This causes a decrease in carbon dioxide and an increase in oxygen in the blood and results in a variety of unpleasant sensations, such as stabbing pains in the chest, tingling of hands and feet, tightness of the throat, and spasms of muscles almost anywhere in the body. Because the symptoms simulate many serious diseases, they cause fear and worry, and those tensions, in turn, cause increased air hunger.

All of these disorders, though not due to any organic difficulty, can make the person with a nervous breakdown truly sick.

And completely outside his ever-present aches and pains, he is suffering mental tortures that are hard to describe. Everything he sees and feels and knows may seem just a bit distorted and unreal. He may develop fears he never had before — and won't have again once he's cured. He may spend so much time in self-castigation that suicide seems a logical step. He may be unable either to accept cheerfully or to combat successfully life's ordinary buffetings. He is gripped in a pessimism that denies the possibility of recovery.

In sum, he loses the ability to control or modify his environment at the time he is most vulnerable to hurts from that environment.

THE WAY OUT

The cure for a nervous breakdown may be as simple as a talk about the sufferer's problems with a family doctor, a clergyman, a loved one or a close friend, or it may be as complicated as year-long psychoanalysis.

Chances are good that treatment can be brief, even though psychiatric aid must be sought, if the breakdown victim is able to cooperate. Here are the major steps he will probably take on his way back to health and happiness:

1. Since his apparently failing health bothers him most, he should have a complete physical examination to assure himself that nothing is organically wrong.
2. He must realize the need for outside help and be prepared to take it gracefully. He should never be pushed to a psychiatrist or anyone else until he knows he needs to go. But outside help must come.
3. He must stop complaining and pitying himself and take an objective look at his symptoms and problems.
4. He must realize that the cause of his breakdown was a pattern of life unsuited to nature. He must learn that somehow he has gotten on the wrong road in life. Either he must change or his environment must — probably both.
5. He must find his specific mistakes in approaching life and retrain himself into other ways. That may mean accepting something less than perfection, avoiding unnecessary pressures, setting more reachable goals, and — maybe most important — thinking of others rather than of himself.
6. He must find a healthful way to live and useful work to do. He needs pleasant recreation, a bit of plain laziness, plenty of sleep and good food and not too much stimulation from coffee, liquor and cigarets.

Finally, as one doctor points out, he should try to remember that a nervous breakdown is never quite so serious as it seems at the time. It can be cured by encouragement and love, new knowledge on the part of the sufferer and a better way of living.

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Experimentally Induced Abnormal Behavior

NORMAN R. F. MAIER

Is our behavior always motivated in the sense of being adaptive and goal-directed? This question is considered here in the light of experimentally produced frustration behavior in the rat. These studies serve as good examples of the need for many carefully controlled experiments to ferret out the interrelationships between variables. In his interpretation of experimental results, Maier distinguishes sharply between motivated behavior and that which is frustration-instigated. From this, he develops a theory of frustration which is applied to human behavior. Behavior which we observe to be senseless because it achieves no ends or even gets the person into worse difficulties, Maier believes to have been fixed through frustrating and punishing experience. Further punishment serves only to worsen and intensify the behavior. Thus, the original needs should be identified and satisfied.

Dr. Maier is professor of psychology at the University of Michigan and is a Diplomate of the American Board of Examiners in Professional Psychology. His research, which is reported here in part, was the basis for the 1938 outstanding research prize awarded by the American Association for the Advancement of Science. Permission to reprint the article was given by the author and the publishers of *Scientific Monthly*, where it appeared in September, 1948 (pp. 210–216).

Note: Four figures have been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the author's permission.

Most of what we know about abnormal behavior has been learned from the study of mental patients and the way they respond to various forms of therapy. There are, however, a number of problems concerning the nature of the abnormal that can only be solved by experimental procedures with animals. One of these is to determine whether neurosis is a disease peculiar to man. This raises the question of whether man is so subject to the disease because of his superior mentality or whether the disease is primarily the product of man's way of living. It has been said that it takes imagination and intelligence of a high order to experience conflicts and that personality disorders require a complex personality structure. Obviously, the ability to produce true neurosis in animals will make it possible to answer this question.

The second problem concerns the relation of the symptom to the cause of the symptom. Has nature supplied man with protective mechanisms — processes whereby the organism develops certain unusual responses that serve to prevent a worse condition? Thus, if a patient develops hysterical blindness, is this symptom a means for protecting the patient from seeing something in his environment that causes his anxiety and conflict? Further, does a psychosis represent a patient's escape from reality and hence serve as a solution when reality is too stressful? If one deals only with studies of case histories, one can find support for this thesis, because the many events in a case history permit one to find a logical connection between the symptom and some problem in the patient's life. Further, when a child has enuresis, should one seek in this behavior some reason, or some way in which he thereby solves a problem? Could bed-wetting give him attention he desires? Could it be a way of striking back at strict parents? Only when we control the life histories of individuals and purposely produce symptoms can the relationship between a symptom and its cause be studied.

Animal studies permit one to secure the necessary case-history data for such investigation, but in order to use lower animals one must be able to produce behavior disorders comparable to those found in man. Thus, one of the first steps in animal studies of abnormal behavior was acquiring the ability to produce abnormal symptoms under laboratory conditions.

When our work was begun, success already had been achieved in this field. By the use of the conditioning method, Pavlov produced what he called an "experimental neurosis" in the dog. Liddell's laboratory at Cornell followed this line of attack, and Liddell used sheep and pigs as well as dogs in his research. At Johns Hopkins University, Gannt established a laboratory to continue the type of research initiated by Pavlov. These studies clearly showed that stressful and conflictual situations caused basic behavior disruptions. The disturbance was apparent from the facts that training on discrimination problems was lost, the animal became emotionally unstable (struggled and bit at restraining harnesses), and, in general, the docile animal became most uncooperative. Many symptoms akin to those observed in human patients (such as disturbances in heart rate, and peculiar fears) were seen, but their appearance was difficult to separate from reactions of normal individuals. At the time that our work with rats was begun at the University of Michigan, there was some doubt as to whether the changes produced in the animal were a "true" neurosis. The symptoms were regarded as not sufficiently profound to be convincing, and some psychiatrists argued that neurosis in subhuman animals was impossible because animals below man lacked sufficient imagination, they could not have sex conflicts, or they did not undergo permanent personality changes. Even though some of these criticisms seem to depend upon specialized definitions of neurosis, which exclude the disease from lower animals by defining it as a human disease, it seemed at the time that part of the failure to accept neurosis in animals was based upon the facts that the behavior disturbances observed were not profound enough and that the behavior was produced by a specialized aspect of the conditioning method.

It is probable that the attention our study received in 1938 was influenced by the fact that the disturbance produced in the rat was extremely violent and left no doubt about its being abnormal. The abnormal behavior was in the form of a seizure in which the rat ran madly in a circular pattern. This running was so violent that the nails of the feet became torn. It was not a typical fear pattern, because shelter was not sought and the animal often ran into table legs and walls. The running phase frequently was followed by a convulsion, which was similar to that produced by drugs; since then we have actually found that the convulsions produced by metrazol have a good deal in common with those produced in the training situation. After the active part of the seizure had passed (one or more minutes), the rat became very passive and its righting reflexes were either absent or greatly depressed. During this period the animal could be molded into almost any position, where it would remain for several minutes — sometimes as long as twenty minutes.

The situation for producing this behavior was built around our interpretation of the conditioning studies. It seemed that behavior disturbances in the earlier studies arose when an animal was trained to give a certain response to a signal and to withhold the response when a different signal was given. When these signals were made more and more alike, the animal had difficulty in determining whether to express or withhold the response. By the presentation of a signal that was as much like the withholding signal as the arousal signal, the animal was stimulated to express and withhold the response at the same time. This was a conflict between doing and not doing which we regarded as a basic conflict.

To incorporate this condition in our experiment, we trained rats to discriminate between two stimulus cards in a jumping apparatus. . . . The rat was trained to jump a short distance from a platform to one of two doors to which the cards were attached. When it chose the correct card (the one with a white circle) this card yielded to the jump and gave the rat access to food. When the rat jumped to the wrong card (the one with the black circle), this card remained in place and the animal received a bump on the nose and fell into a protective net below. Under these conditions animals soon learn always to choose the reward card and to avoid the punishment card. After the discrimination is well learned the situation is changed so that only one of the cards is presented. If this card happens to be the punishment card, the animal, as may be expected, refuses to jump. In order to cause the animal to jump to the punishment card, it is necessary to drive him. This is done by using a jet of air and directing it on the rat. When released, the air makes a hissing noise and is irritating to the rat; consequently the resistance to jumping is broken. The condition of driving the rat to make a response to a card it has been trained to avoid was considered a conflict between doing and not doing, and it was the condition under which the violent seizures most frequently were produced.

These experiments raised two interesting questions: Was the seizure produced by the conflict, or by the sound of the air? Is the seizure akin to an epileptic attack and, therefore, an abnormality other than a neurosis? The implication of the second question is that the symptoms observed are too profound to be considered a neurosis.

Experimental studies concerning these and other points have been numerous. Our laboratory alone has contributed more than 25 studies, and a total of perhaps 150 studies have been published on some aspects of the rat's abnormal behavior. The studies include the effects of diet, drugs, heredity, emotionality, and brain injury on seizure susceptibility, as well as studies directed toward determining the nature of the abnormality.

At the present time it seems quite clear that the basic condition for producing the disturbance is conflict. The same auditory conditions, with and without the element of conflict, produce different results. The delay in settling this issue was due to the fact that auditory stimuli, such as the hiss of air, the sound of buzzers and bells, the jingling of keys, supersonic tones, and pure tones of low pitch all produce seizures in some animals. To explain these seizures it was necessary to show that these conditions also produce conflict. Certain sounds are irritants and arouse generalized escape behavior. However, when the animal is confined it is driven to escape, but at the same time its escape is blocked. Thus the animal is trapped in a situation which demands responses and yet inhibits those responses. It has been shown by Dr. Marcuse, of Cornell University, that seizures do not occur when the sound source is fastened to the animal. Under these conditions the escape behavior is permitted even though escape is not accomplished. It has also been shown that the type of confinement and the type of responses made during auditory stimulation influence the appearance of seizures. These facts indicate that auditory stimulation as mere sound stimulation is inadequate for producing seizures. Rather, other conditions must be present, and these other conditions determine whether behavior tensions are built up without permitting a release through some avenue of behavior. It is when these tensions become too great that they break forth as a seizure.

The fact that smoke, water spray, and electric shock (applied during conflict) also produce seizures under proper conditions indicates that sound is not unique in its seizure-producing qualities. Since the expression of escape behavior prevents seizures, one is led to conclude that behavior must be blocked while irritants are applied.

The mere fact that conflict and unresolved tensions seem to be essential for producing seizures makes the seizure appear to be a form of neurosis rather than the epileptic attack of a defective organism. Perhaps Dr. Goldstein's classification, "catastrophic reaction," is more adequate than neurosis, since this term implies a form of disorganized behavior which occurs when the environment places demands on the organism that it is incapable of handling. Either "neurosis" or "catastrophic reaction," however, places the emphasis on the abnormality as being one that is situation-induced rather than the response of an injured or defective organism.

Because of the profound nature of the seizure, other aspects of the abnormality reported in our rats frequently have been overlooked. The conflict situation in the rat was highly frustrating and produced nervousness which extended outside the situation. Experimental rats become less likely to breed, and they develop a retiring nature. These behavior alterations are akin to personality changes, since they extend outside the test situation. Further, and more important, is the fact that the frustrating situation produced compulsive behavior in many of the rats, particularly those not showing seizures. Compulsive behavior commonly appears in neurosis and is one of the most difficult to explain. A classical illustration of compulsive behavior is Lady Macbeth's repeated hand-washing, which is regarded as an effort to cleanse herself from guilt. Because compulsive behavior is a fundamental type of abnormality, it was selected for special study. Thus, from the outset, our studies of abnormal behavior in the rat have dealt with two distinct forms of abnormality.

When a rat is placed in the card-discrimination problem situation in which reward and punishment are applied in a random order, the animal is confronted with an insoluble problem. This fact is soon recognized by the animal, and it expresses its recognition of such a difficult problem by refusing to choose between cards. This refusal is so intense that hunger is not sufficient to cause the animal to take a 50–50 chance on happening to strike the reward card. In order to overcome this resistance, the animal is driven with a blast of air, as described earlier. Occasionally, seizures are produced in this situation, but more commonly the animal jumps at one of the cards, and soon its choices follow a consistent pattern. Usually the rat chooses a card on a position basis, i.e., it chooses the card on the right (or left) side, regardless of which of the cards it is. Once the rat ceases trying out various possibilities and makes its choice on a position basis, this way of choosing becomes the response to the insoluble problem, and the animal never deviates from this procedure once it is established. In practicing the position response, the animal is punished on half its choices and rewarded on the other half, since these are applied in random order. Such a condition should not establish a preferred way of responding, yet under frustration a highly specific response becomes established.

Other animals can be *trained* to show similar position responses. This is accomplished by rewarding animals for choosing the cards on a position basis. Such animals are *motivated* to express position responses, whereas the animals in the insoluble problem situation express their position responses as a consequence of *frustration.*

The question now is, Are responses established under frustration different from those established through motivational training?

It is found that animals that acquire their responses under frustration cannot substitute them for other responses. In other words, they cannot learn new responses even when the situation ceases being insoluble. Not only are they unable to adopt new responses, but they are unable to drop their inadequate position responses. This is true even if they are punished each time they express their old responses. As a matter of fact, punishing them for making their former responses makes them *more* likely to repeat them in the future. Animals with such frustration-induced position responses will choose the punishment cards whenever they are placed on the side of the animals' position preferences. They will even refuse to jump to an open window in which food is clearly displayed when its position does not correspond with their position reaction.

This rigid behavior is in contrast to that of animals that have acquired their position responses under conditions of motivation. These animals readily learn new responses when training conditions are changed, and they are constructively influenced when being punished for errors. If punished too severely, however, they, too, may become frustrated, and they then behave like the above-mentioned animals.

Because frustration makes behavior rigid and unchangeable, we have called the responses acquired under frustration "abnormal fixations" to distinguish them from normal habits. The adjective "abnormal" is used because the strength of the response does not follow the principles of learning in establishing or fixating habits.

Abnormal fixations not only are rigid but they have a compulsive character. This trait can be demonstrated in the following manner. Suppose that after a period of frustration a rat's jump to the card with the white circle is always rewarded, whereas a jump to the card with the black circle is always punished. In this situation a rat with a right-positional fixation will receive punishment whenever the card with the black circle is on the right side, and reward whenever the card with the white circle is on the right side. After a time in this situation, the rat begins to hesitate to jump whenever the punishment card is on the right, or position, side. When forced to jump it strikes the card with its rump to avoid a bump on the nose. When the reward card is on the right side, however, the animal jumps readily and hits the card with its nose and forepaws. It is evident that the animal knows which card punishes and which card rewards, and, although it expresses its knowledge of the difference in the cards by the way it jumps, it does not choose the card to jump to on this basis. The right-position fixation apparently prevents the rat from making an adaptive response to the situation, so it is forced to take punishment even though it knows better. This unadaptive behavior is in contrast to that of animals with normal position habits. As soon as they learn which card punishes and which card rewards, they abandon their position responses and, instead, follow the reward card from right to left.

Behavior similar to the abnormal fixations in rats has been demonstrated in college students by Dorothy Marquart, one of our graduate students. After mild frustration in any insoluble problem, the time required by students to learn a simple problem is greatly increased. Since all learning requires the acquisition of a new response, any resistance to change that is produced by frustration results in retarded learning. As might be expected, individual differences were apparent. Some of the students were not frustrated by the mild shock and learned at the normal rate. Those that were frustrated, however, required many more trials than the slowest of the normal learners.

The abnormal fixation is akin to rigid responses found in human beings. Accounts of compulsive behavior, such as is found in kleptomania, phobias, and alcoholism, are common in the literature of abnormality. So-called ritualistic behaviors, in which the person must repeat a senseless routine of activities, are further examples. The fact that some attitudes are rigid and not subject to modification, regardless of how senseless they are from a logical point of view, suggests that they are fixated. Of interest are the facts that rigid attitudes are emotionally loaded and are commonly associated with objects that are threats to a person's security. These observations support the suggestion that rigid attitudes have their basis in frustration. Thus, attitudes on socioeconomic topics, racial questions, and religious questions are least subject to modification, and these attitudes are most rigid during periods of frustration and stress.

The studies of abnormal behavior in the rat lead to a new theory of frustration. They demonstrate that behavior elicited during a state of frustration has certain unique properties, and that these properties make frustration-induced behavior different in kind from that produced in a motivated state. This basic separation between motivated and frustrated behavior is in contrast to the view which postulates that all behavior has a motive. When it is assumed that all behavior is motivated, it follows that any behavior expressed is a *means* to some *end*. Thus, one is led to assume that if a child steals he is doing it to achieve some goal, or end. It is said that he is solving the problem of satisfying his wants or needs, even though he may be going contrary to some other needs, such as being accepted by society. From this point of view it follows that if we make stealing unattractive (punishing for the act), such behavior will be deterred. If, on the other hand, we recognize that there are two different kinds of behavior, then it follows that there may be two kinds of stealing, one that is motivated and solves the problem of gratifying needs, and one that is frustration-instigated and compulsive in nature. The latter type of behavior solves no problem and has no goal to direct it. It may occur in children from broken homes in which the child has adequate spending money. This type of stealing may involve the theft of objects for which the child has no need or interest. Such behavior is similar to vandalism, in which objects are destroyed rather than taken. The fact that stealing increases with frustration indicates that we must distinguish between the various forms of stealing. The separation of behavior into frustration-instigated and goal-motivated behavior permits just such a distinction.

Once we accept the belief that behavior produced under frustration follows different principles from behavior motivated by goals, we can reorganize our knowledge of the subject of frustration. For example, it is known that destructive (aggressive or hateful) behavior is associated with frustration and that a frustrated person attacks his enemy. This behavior may appear to be problem-solving in nature, but difficulty is encountered in explaining why people who are frustrated so often strike out at innocent bystanders. One can see how the destruction of one's enemies would achieve objectives, but the fact is that frustrated persons do not always express their hates in such a manner as to solve problems. Instead, they create more problems by their hateful behavior. Thus, frustrated parents abuse their children and rationalize that they are training them. The children return the hatred or direct it toward society through delinquent behavior.

It seems useless to probe for problems which hate behavior solves. Instead, our theory suggests that frustration produces hate, and the hatred is directed toward anything that is convenient or is in the individual's attention during his frustration. Some of the animal experiments show that the type of behavior expressed in frustration is determined by its availability to the individual rather than by its effectiveness.

Another form of behavior associated with frustration is that of regression, which represents a type of behavior more childish than the individual's level of development warrants. Thus, bedwetting in an eight-year-old is a sign of regression. A child that has learned to walk may temporarily revert to creeping when frustrated. Believers in the theory that all behavior is motivated have difficulty in explaining such senseless regressive behaviors. What problem is solved by this type of behavior? Frequently, it is said that the child desires attention. The attention he receives from bed-wetting, however, may be a spanking and degradation. Is this activity solving a problem for the child, or is it aggravating a condition that is already bad? If, however, we assume that frustration produces regression and that this simplification of behavior is a direct result of frustration, then our problem is to seek the source of frustration. The child that regresses may feel rejected. Punishment makes him feel more rejected. On the other hand, love and understanding reduce the state of frustration. It then follows that a child is most likely to be cured if he is given treatment that reduces his frustration, and this is frequently what the practicing psychiatrist recommends. He suggests love and attention because they work. Nevertheless, from a motivation point of view, rewarding a bad response with love should strengthen it. Yet both aggressive and regressive behaviors are reduced when treated with understanding and love.

From our point of view it follows that the behavior expressed gives no clue as to what the frustrated individual needs. A child that is insecure may develop a form of ritualistic behavior and so show signs of fixation; he may whine excessively, wet the bed, and have difficulty in learning, thereby showing signs of regression; he may become destructive with toys or be a bully in school, thereby showing aggressive symptoms; or he may show behaviors that are combinations of fixation, regression, and aggression. Regardless of which behaviors are expressed, however, the underlying cause may be the same. If the insecure or rejected child is to be made to feel secure, therapy is achieved in the same way, regardless of the specific symptoms that a given child exhibits.

To show more clearly the difference between motivated and frustrated behavior, we have listed in Table I those characteristics of each that seem to be sufficiently common to warrant inclusion (although there may be many others).

TABLE I. Characteristics of Motivated and Frustrated Behavior

Motivation-Induced	*Frustration-Instigated*
Goal-oriented	Not directed toward a goal
Tensions reduced when goal is reached	Tensions reduced when behavior is expressed, but increased if behavior leads to more frustration
Punishment deters action	Punishment aggravates state of frustration
Behavior shows variability and resourcefulness in a problem situation	Behavior is stereotyped and rigid
Behavior is constructive	Behavior is nonconstructive or destructive
Behavior reflects choices influenced by consequences	Behavior is compulsive
Learning proceeds and makes for development and maturity	Learning is blocked and behavior regresses

The differences in behavior listed in the table are basic, and failure to make these distinctions seems only to lead to inconsistencies and confusion. If these differences are recognized it means that the first step in diagnosis is to determine which condition an individual is in when one attempts to correct behavior. The nonfrustrated person is subject to training because he is responsive to training methods, and he can be attracted to substitute goals.

The frustrated individual, however, needs relief from frustration. Can the situation be corrected? If so, then such correction is a form of therapy. Another possibility is to treat the *individual* rather than the *situation*. Can the state of frustration be relieved without making it necessary to change the situation? Actually the expression of a frustrated response reduces the state of frustration. An act of aggression such as writing a hateful letter achieves relief even if the letter is not mailed. Crying (a regressive response to frustration) reduces frustration and the person need not receive the concessions that tears sometimes attain. Rats which showed tendencies to have seizures when frustrated, had fewer seizures when they developed fixations. Thus the various frustration-induced responses seem to relieve the state of frustration, but it must not be supposed that the anticipation of such relief is an essential cause of the behavior. To make this supposition would deny the basic evidence which differentiates motivated and frustration-instigated behavior.

Unfortunately, the expression of frustration-instigated responses frequently leads to further frustration. When one strikes another or verbally abuses him, the other person strikes back and so creates a further problem. Thus the value of the relief gained through expression is offset by the fact that the end the expression has served is one which leads to new frustration. It is for this reason that therapy must permit harmless forms of aggression. Such harmless forms of aggression are encouraged in play therapy and in counselling situations. These permit children and adults to express hostility without having the behavior challenged.

We thus find that the experimentation with animals leads us to a theory of frustration which reorganizes the facts of human behavior and reinterprets the meaning and importance of certain forms of therapy. It has supplied us with certain basic principles which have a firm foundation in that the principles are experimentally derived. Whether the experimentation can proceed to aid us in answering many of our perplexing problems remains to be seen.

Certainly the world situation offers many problems. To what extent are we reading motives into the frustrated behavior of nations with which we come in conflict? To what extent are our behaviors frustrated reactions rather than problem-solving reactions? Can a frustrated world solve its problems? If therapy is needed, who or where can one find a disinterested party that can make the diagnosis? The frustrated person rationalizes and justifies his feelings and actions, and for this reason the patient cannot easily treat himself. Is this also true of the behavior of nations?

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SUGGESTIONS FOR FURTHER READING

Butler, R. A. Curiosity in monkeys. *Scientific American*, February, 1954, pp. 70–75. Some evidence that in primates curiosity is a basic drive similar to hunger, thirst, and the others.

Hall, Calvin S. *A Primer of Freudian Psychology*. Cleveland, Ohio: World Publishing Co., 1954. A concise presentation of Freud's conceptualization of the normal personality, written by the author of selection 37.

Masserman, J. H. Experimental neuroses. *Scientific American*, March, 1950, pp. 38–43. Experiments in which cats are used are somewhat similar to those which Maier reported on rats but with the additional feature of applied therapy.

Remmers, H. H., and D. H. Radler. Teenage attitudes. *Scientific American*, June, 1958, pp. 25–29. A survey of several thousand adolescents reveals their strong motives toward conformity.

Symonds, P. M. What education has to learn from psychology: I. Motivation. *Teachers College Record*, February, 1955, pp. 277–285. A good summary of the major principles of motivation and how they may be applied to the direction of a child's learning. ing.

Woodworth, R. S. *Dynamics of Behavior*. New York: Holt, 1958. A standard text which treats the problem of motivation and its relationships to learning, perception, and thinking.

PART VII

The Behaving Organism Is Biological

Any complete understanding of man's behavior must include a knowledge of the biological mechanisms which account for the sensitivity to stimulation, the response displayed, and the complex communication and integration network which lies between. In other words, a knowledge of our organic system is necessary to an understanding of our behavioral acts. We must remember, too, that there is no psychological structure smaller than the whole person, and that all attempts to locate the hypothetical "little man" who supposedly directs our activities have utterly failed. Such attempts we now recognize as outmoded (but unhappily not forgotten) remnants of our cultural heritage.

Study of the organism and behavior is the specialty of the physiological psychologist. He examines any bodily structures or functions which influence behavior. He is not looking for the "seat of behavior" in the body nor the "locus of consciousness" in the brain, but rather is concerned with causal variables in physiology which can be appropriately integrated with causal variables from other sources to complete the picture of natural forces which shape our behavior. He knows, for example, that we see with our eyes but that we do so in terms of our experience, and within a socially determined frame of reference.

Traditionally, physiological psychologists have placed primary stress upon the three organ systems most directly involved in the stimulus-response pattern: the sensory, the motor, and the nervous system. Sometimes it seems that this emphasis has blinded them to the role of other biological functions which may be of equal importance. On the other hand, the approach may be justified by the belief that these three systems are directly involved in behavior, whereas the other physiological systems are less directly involved.

Not all psychologists are equally concerned with internal functions such as those discussed in the selections of Part VII. Some prefer to treat behavior as output, relating it directly to stimulus input or to input through a time sequence. Thus they neglect the contribution of the organism, ascribe to it "intervening" but biologically unstructured hypothetical variables, or merely treat it as a more-or-less mysterious "black box." Although such a psychology has unquestionably contributed to the furtherance of psychological sophistication, it can scarcely hope ever to develop a complete system of behavior science.

In Part VII only a few of the many interests of the physiological psychologist are represented. Bertalanffy, in the first selection, discusses three significant biological topics which relate to behavior — body structure, growth, and the brain. He also is concerned with symbolic inventions which he presents as a consequence of man's unique brain structure. The emphasis which many psychologists place on the brain is reflected in the next three selections, each with a rather different point of view of its importance to a science of behavior. Sir Russell Brain holds to a mentalistic interpretation ("events in the brain . . . being . . . both physiological and mental . . ."). Ayer points out some very serious difficulties with a dualistic view and feels that the mind-body problem can be simplified considerably. But Sperry has quite a different slant on how psychologists may treat the brain in his behavior system. In the next selection Strange reviews some important research which gives insight to the importance of the glands in integrating behavior. Then follows a brief selection about heredity as a contributing factor in both physical and psychological traits. Sensory psychology and physiology are represented in the two final selections. Some interesting features of vision are delightfully discussed in a nontechnical manner by Dr. O'Brien, and the sense of taste is surveyed a bit more technically by Dr. Biedler.

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A Biologist Looks at Human Nature

LUDWIG VON BERTALANFFY

Man is a biological creature as well as a psychological creature. His biological characteristics are foundations which support many of his psychological characteristics, but this does not mean that you can reduce behavior to biology any more than you can reduce biology to physics and chemistry. Dr. Bertalanffy explores some of the understanding of biology which the behavior scientist should master and points out four linkages. The author gives examples of structural features which relate on the one hand to evolutionary development and on the other hand to mechanisms which permit or limit behavior. He goes on to explore learning and the differences between man's growth curve and that of other animals. Relative brain size and the differential growth of certain brain parts is the third foundation the author discusses, although his view of the psychological role of the brain should be contrasted with that of Sperry (selection 47). Finally, Bertalanffy traces in some detail the emergence, in man only, of symbolic tools which he believes rests upon the immense forebrain. Although the student will recognize this idea from previous selections, the consequences of man's symbolic accomplishments are treated here in a challenging manner for the behavioral scientist.

Dr. Bertalanffy has worked in the fields of physiology, medical biology, biophysics, and philosophy. He was formerly a Senior Fellow of the Center for Advanced Study in the Behavioral Sciences at Stanford University and is now Research Director at Mt. Sinai Hospital, Los Angeles. This selection appeared in the January, 1956, issue of *Scientific Monthly* (pp. 33–41), and is reprinted by permission of the author and the publisher.

Biology, in the usual college curriculum, consists of looking, under the microscope, at amoebas and paramecia and dissecting earthworms, dogfish, and an odd number of other animal species. The trouble with conventional training in the natural sciences is that it presents well enough a smaller or larger body of facts and methods but carefully skips those questions and results that have a bearing on our picture of the world and man (*1*).

To a large extent my personal experience has been with medical schools, and I have found it extremely difficult to persuade the professor of medicine or surgery, the gynecologist, or even the anatomist that modern biology can do somewhat better than present a number of rather irrelevant facts for use on examinations. I am afraid that a similar conception of biology is prevalent also among many behavioral and social scientists. In fact, biology is one of the foundations of behavioral science. To begin with, it will be well to make clear in what sense this is true.

LEVELS OF SCIENCE

Without entering into epistemological niceties, we may say that the field of science consists of three levels: physical nature; organisms; and human behavior, individual and social. In the way of an idealized graph, the scale of nature may be represented as is shown in Fig. 1.

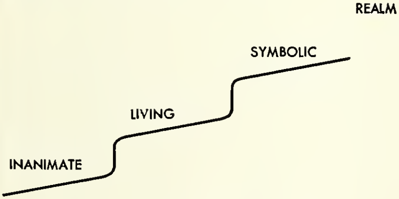

Fig. 1

I shall not discuss the question of how these levels are connected. It appears that they represent distinctive steps, although not discontinuities, somewhat in the way the mathematician speaks of step functions. There are intermediates between the levels of inanimate and living nature, such as the viruses, and again intermediates between animal behavior and the symbolic behavior characteristic of man. There is no doubt, however, that the notion of emergence is essentially correct. Each higher level presents new features that surpass those of the lower levels.

Here a first important consideration arises. The quest for the unity of science often has led to the postulate of reductionism: namely, that biology should eventually be reduced to physics and chemistry, and that the behavioral and social sciences should be reduced to biology. Now biologism, the thesis that human behavior should be reduced to biological terms and laws, is, in some respects, a much more serious affair than physicalism, the tendency to reduce biology to physics and chemistry. The question whether biological terms and laws can be expressed by the terms and laws of physics is a fine playground for mental calisthenics and an academic problem to be settled by recourse partly to epistemological analysis and partly to concrete research. The question whether human behavior can be expressed in biological terms is far from purely academic. If we assume that the thesis of biologism is correct, it follows that human behavior is to be considered a particularly involved complex of the ways and factors of behavior that are present in subhuman species, in the same way that, for physicalism, a living organism is a particularly intricate physical system. If human behavior and history are only a product of biological factors, one of the most important factors must be heredity. What really matters, then, is not the individual or the culture but the hereditary substratum of the nation or race, and this quite logically leads to the notion of a master race and eventually to the justification of extinguishing others.

If man is to be considered only from a biological viewpoint, war appears as the continuation of the omnipresent struggle for existence. Since, according to current biological theory, survival and selection in the struggle for existence are the principal motors of evolutionary progress, war appears to be the touchstone for the value of a nation or race, and the surviving one has by this very fact proved its superiority. If human behavior and society have, in principle, the same bases as animal behavior and society, it follows that the most desirable form of society would be one like that of ants or termites. Actually these are much more perfect and satisfactory than human society, since there is no social question, unemployment, or frustration of individuals. In other words, what really matters is not the individual but the supraindividual whole of the state, nation, or race. Then the human individual becomes an expendable short-lived cell in the all-important whole.

These consequences, the theory and practice of a master race, total war, and the totalitarian state, are quite logical once the thesis of biologism is accepted. Of course, other and more ingratiating doctrines can be derived equally well from biological considerations. However, if biological categories are taken as the only measure, such consequences do arise easily and actually have in recent history.

Refusing biologism does not mean that we can neglect biology as the most important groundwork of behavioral science. The situation is similar to that in biology. Hardly any modern biologist will contend that a simple application of physics and chemistry will explain the working of a living cell or organism. No biologist can work intelligently or hope to discover even a shred of the laws governing living things if he does not thoroughly apply physical and chemical knowledge, methods and principles, to the extent that a modern biological laboratory is hardly distinguishable in appearance from a laboratory of physics or chemistry.

It is in this vein that I wish to give a bird's-eye view of some biological fields that are of importance to behavioral science. This survey may be conveniently organized under the aspects of the evolutionary, developmental, neurological, and symbolistic foundations of human behavior.

EVOLUTIONARY FOUNDATIONS

The ancestral series of man is not established quite so well as that of the horse or the elephant but it can be followed fairly closely. There is no need to elaborate in this brief presentation on our knowledge of the descent of man. However, one thing to be mentioned is the preservation of primitive anatomical characteristics in the human organism. An example is the hand (which still shows the primitive ground plan of the five-fingered mammalian) and the vertebrate limb, as compared with the specialization found in the hoof of ungulates, the fin of aquatic mammals, and the wing of bats. Another primitive feature is the preservation of pronation and supination of the forelimb in man, as opposed to the fixation of the pronate position of the radius and ulna in other mammalian orders. This, together with the opposability of the thumb, makes the hand the versatile instrument of *Homo faber*. A similar primitivity and lack of specialization is preserved in the teeth. The low specialization and relative reduction of denture, as compared with the anthropoids, leads to the subordination of the facial cranium to the braincase in man.

Progressive changes, on the other hand, are the increase in the size of the eyes, the reduction of a brutish muzzle, and the forward shift of the eye axes. This makes possible the overlapping of the fields of vision of both eyes and is the basis of binocular vision and perception of spatial depth. The evolution of erect posture and gait not only led to transformation of the hind leg but also made the hand free to become a prehensile organ, a change further reflected in the evolution of the brain. It also unburdens the musculature of the neck and leads to the reduction of the cranial relief that is so prominent, for example, in a gorilla's skull. It may be mentioned that even in modern man erect gait is not perfectly established. A number of pathological changes, such as flat feet, hernias, varicose veins, and certain women's diseases, are a consequence of this fact.

In view of the intercorrelation of these and many other characteristics, it is difficult to indicate the primary factors in the evolution of man. Two features, however, appear to be of outstanding importance. One is a change of the hormonal balance, which, ontogenetically, leads to a retardation of development and, phylogenetically, to a conservation of primitive characters. The other is the increase in brain size.

Bolk has emphasized that human development, if compared with the development of anthropoids, appears to be retarded in a number of characteristics. For example, the skull of the baby chimpanzee is much more human than that of the adult chimpanzee with its massive prognathism, heavy eyebrow arches, and so forth. On the other hand, disturbances of the hormonal balance may lead to a reappearance in man of such simian characteristics as prognathism, hypertrichosis, and precocious puberty. It has been said that man is a "sexually matured anthropoid fetus." This statement, like the news of Mark Twain's death, is slightly exaggerated. Recent studies by Kummer (2), using D'Arcy Thompson's method of coordinate transformation, have shown that the human skull cannot be considered simply as a product of "fetalization" of the anthropoid skull. Rather, it is differentiation in another direction, owing to the increase in size of the brain and the neurocranium.

But, even though Bolk's formulation is oversimplified, there is no doubt that the general principle of retardation is correct in many respects and that it has important consequences for man's position in nature.

Animals are anatomically adapted to a particular environment. A horse is an animal of the steppe, a whale is a natant animal, a monkey is an animal climbing in the forest. In contrast, man has preserved many primitive features and has not developed highly specialized adaptations. According to von Uexhüll's doctrine, the organization and specialization of an animal is decisive for what enters into its ambient world. Of the great cake of reality, an animal cuts a slice, so to speak, of what becomes stimuli, to which it reacts in correspondence with its inherited organization. The rest of the world is non-existent for that particular species. In contrast to the organization-bound ambient of animals, man has a universe, to use an expression of Gehlen (3). Any section of the world, from the galaxies that are inaccessible to direct perception and biologically irrelevant down to the equally inaccessible atoms, can become an object of interest to man. Thus man makes a virtue out of his biological helplessness. Precisely because he is lacking organic and instinctual adaptation to a specific environment, he is able to conquer the whole planet from the poles to the equator. So man creates his own ambient, which is what we call human culture. This, however, would be impossible without a second basic factor: the growth of the brain.

The increase of brain size in the series of mammals is probably the most important example of orthogenesis — that is, evolution in a certain direction. It follows the principle of allometric growth that generally governs the increase in the size of organs with increasing body size. As an over-all approximation, it appears that brain size in the series of mammals "from the mouse to the elephant" is roughly proportional to the 2/3 power of weight; that is, it follows the surface rule that is characteristic of many physiological processes (4). In detail, there are complications not settled in an extensive and somewhat controversial literature. (For a review of recent theories on the increase of brain size, see 5.)

According to the classical theory of Dubois, the increase of brain size is composed of two factors. First, so far as closely related species are concerned, brain size increases allometrically with body size. Second, if different mammalian orders are compared, there is progressive cephalization — that is, a jumplike duplication of brain size with the transition from one group to another. Thus, in the series of shrew, mole, primitive and higher ungulates, anthropoids, *Pithecanthropus*, and man, brain weight (calculated for equal body weight) increases in a ratio 1 : 2 : 4 : 8 : 16 : 32 : 64. Dubois' theory is not to be regarded as proved or generally accepted, but there is little doubt that the evolution of the brain follows rather simple mathematical laws.

In absolute size the human brain is one of the largest surpassed only by such giant forms as the whale and the elephant. In its relative size, or brain weight per unit of body weight, it is at the top of the series; relative brain weight is larger only in a few small mammals and birds, in which obviously brain size is correlated to the high intensity of their metabolism.

The allometric growth of the brain in the series of mammals amounts not only to a quantitative increase but, as Rensch (6) has recently shown, further entails changes in the architecture of the brain, providing cerebral areas that can be used for higher functions. It also leads to histological changes and possibly differences in view of instinctive and learning behavior. It may be mentioned in this connection that the ventral region of the frontal lobe, where the motoric speech center is localized, is lacking even in anthropoids and appears only in man. In contrast, the temporal lobe, where, in man, the sensory speech center is located, is rather well developed in animals. Consequently, animals like the dog, the elephant, or the horse learn to obey spoken commands and, so, obviously have acoustic gnosia of speech, which is lost in dogs after destruction of this region. The possession of the motoric speech center is connected with the verbal and symbolic abilities of man.

GROWTH AND DEVELOPMENT AS BASES OF BEHAVIOR

Let us now take a look at growth and development as bases for human behavior. Growth, in its quantitative aspects, can be considered under two major viewpoints: growth in time, the increase of measurable quantities in the organism as a function of time; and relative growth, the ratio between different growth rates of parts in an organic system which eventually leads to changes in proportion. I have already discussed an evolutionary aspect of relative growth as shown in progressive cephalization.

The time curve of growth in mammals, fish, crustaceans, clams, and other animal classes follows a pattern, which is characterized by the fact that it approaches a final weight by way of an S-shaped curve. These characteristic growth curves, as well as different ones found in other groups, such as insects and snails, can be explained and predicted by a theory of "growth types and metabolic types" (*5, 7*), which, in principle, is based on the consideration of growth as the result of a counteraction of the building up and breaking down (anabolism and catabolism) of the body constituents. Since its pattern is essentially the same, the growth of different species, such as a fish, a mouse, an elephant, or man, can be represented by the same curve. Only the scales of units of time and size are different.

In such comparison, only one organism, man, makes an exception. In its first part, the human growth curve is distinguishable from that of all other animals in that a growth cycle seems to be added, so that the infant period is greatly prolonged and the steep, almost exponential increase in size, as is characteristic for early postembryonic growth in animals, is avoided. This difference in the growth curve may appear to be an insignificant detail, but it has tremendous consequences. The abnormal shape of the human growth curve is, of course, a quantitative expression of the retardation and hormonal shift mentioned earlier. Thus animals run swiftly through the period of their somatic and behavioral growth, and soon sexual maturity is reached. In contradistinction, the characteristic shape of his growth curve gives man his uniquely long period of youth and the opportunity for a long period of learning and mental development. It is an indispensable prerequisite of human culture.

This is connected with another interesting characteristic. We can distinguish in birds and mammals between nidifugous and nidicolous species: those in which the young reach independence and leave the nest early or those that are born in a rather undeveloped state and need parental care for a long period. Compare a kitten born blind and helpless with a young colt. This difference depends on the index of cerebralization — that is, the ratio of the hemispheres to the brain stem. Nidifugous species are the more advanced forms with higher cerebralization. Man, as Portmann (*8*) has emphasized, represents the unique case of a secondary nidicolous. Corresponding to his high cerebralization and owing to his long gestation period, he is born at a stage that would anatomically correspond to that of a nidifugous animal. Nevertheless, behaviorally he is nidicolous. Here we possibly have one important biological root of mother fixation, the Oedipus complex, and other psychoanalytic items. The role of the "biological helplessness" of the infant has already been emphasized by Freud (*9*). The human baby needs and receives extensive maternal care at a time when his sensory and neural equipment is well completed. This is a situation that is rather unique in the animal kingdom. Perhaps even the suggestion can be made that this early fixation is of the nature of an imprinting mechanism in the sense of Lorenz (see *10*), fixing an image in a state that is advanced enough neurologically to make this possible but early enough that such rather primitive determination of behavior can still take place.

In passing I would like to mention that, in all probability, the somatotypes of man are essentially a phenomenon of relative growth. One cannot speak of a cycloid or schizoid personality without taking into account the theory of body constitutions as developed by Kretschmer in Germany and by Sheldon in this country. In their present stage, these theories are certainly exposed to serious criticism. However, the typology of somatic constitutions and their connection with psychological predispositions and mental diseases, as formulated independently by different authors, shows close correspondence, and this is an indication that, to a certain extent, it corresponds to reality. As Conrad, a follower of Kretschmer, has emphasized, the somatotypes are the expression of a different harmonization of growth rates, "bundles of correlated growth principles." It is remarkable that Conrad's analysis (*11*) of the types of constitution in man closely approaches the conceptions of a "dynamic morphology" that I developed (*12*) in the rather different fields of comparative physiology of metabolism and growth.

EVOLUTION OF THE BRAIN

Speaking again in the way of a crude oversimplification, which is likely to incur the well-deserved indignation of the neurologist, the neurological evolution in vertebrates can be conceived of as being a superposition of three major levels of neural apparatus piled up in the course of evolution. The oldest part is the spinal cord, which is present in *Amphioxus* as a rather remote ancestral form and is essentially an apparatus of reflex response. Superimposed on the spinal cord, the brain develops in the series of vertebrates. This evolution takes place in two major steps. In accordance with the increasing development of sense organs, massive ganglia are developed at the anterior end of the spinal cord as an apparatus to react to sensory stimuli. This primeval part of the brain, known as the paleencephalon, is present almost alone in the fishes, but it keeps its importance as far as man. Superimposed on it, the enormous neural structure of the cerebral cortex gradually develops. This so-called neencephalon is only rudimentary in fish and increases continually in the series of amphibians, reptiles, birds, mammals, and man.

In man the paleencephalon becomes the organ of primitive functions and the mediator between the cortex (the organ of consciousness) and the neurohumoral system. The cortex is the organ of the day personality of conscious perception, feeling, and voluntary control of action and, in particular, of the symbolic activity characteristic of man.

This, however, has certain gloomy aspects. If we survey the evolutionary series of brains from the lower vertebrates to man, the characteristic is progressive cerebralization — that is, the increase in the quantity and complexity of the forebrain. What is called human progress is a purely intellectual affair, made possible by the enormous development of the forebrain. Owing to this, man was able to build up the symbolic worlds of speech and thought and some progress in science and technology during the 5000 years recorded history was made.

Not much development, however, is seen on the moral side. It is doubtful whether the methods of modern warfare are preferable to the big stones used for cracking the skull of the fellow-Neanderthaler. It is rather obvious that the moral standards of Laotse and Buddha were not inferior to ours. The human cortex contains some 10 billion neurons that have made possible the progress from the stone axe to airplanes and atomic bombs, from primitive mythology to quantum theory. There is no corresponding development on the instinctual side that causes man to mend his ways. For this reason, moral exhortation as proffered through the centuries by the founders of religion and great leaders of humanity has proved disconcertingly ineffective. If moral progress is possible, it seems so only in the way of inhibition and sublimation. The inhibitory action of higher centers on lower ones is a well-known fact in neurophysiology. It appears that we cannot change the *bête humaine:* we can only hope that the brute in man is better controlled.

DOMINANCE OF SYMBOLS

"Everything in this world is nonsense; the whole of life is a plethora of ludicrous absurdities, one more fanciful than another. The crown is nothing, the ring is nothing, too. Each would mean nothing but nonsense and empty foolishness except to the eyes which behold the symbolism behind them. Yet they, because of their meaning, dominate the world. Only one form of metal there is, which is a meaning in itself — the sword," said Temple Thurstone (*13*).

What is unique in human behavior? The answer is unequivocal and generally accepted. The monopoly of man, made possible by the evolution of his forebrain that profoundly distinguishes him from other beings, is the creation of a universe of symbols in thought and language.

Man's unique position is based on the dominance of symbols in his life. Except in the immediate satisfaction of biological needs, man lives in a world not of things but of symbols. A coin is a symbol for a certain amount of work done, or food and other utilities available; a document is a symbol of *res gestae;* a word or concept is a symbol of a thing or relationship; a book is a fantastic pile of accumulated symbols; and so forth *ad infinitum.*

Symbols can be defined as signs that are freely created, represent some content, and are transmitted by tradition. It appears that the characteristics indicated are necessary and sufficient to distinguish symbolism, and language in particular, from subhuman forms of behavior.

By "freely created" I mean that there is no biologically enforced connection between the sign and the thing connotated. In conditioned reaction, the connection between the signal and thing signaled is imposed from outside. It may be a natural connection, as when a child or kitten seeing a flame moves to avoid the fire, because the child or the kitten has previously been burned. Or the connection may be abitrary and imposed by the experimenter, as in the case of the Pavlovian dog that learned to secrete saliva when a bell was rung because this was followed by a meal during the conditioning period. In contradistinction, there is no biological connection between the words, *father, pater, père, otec* (or whatever the word may be in any language) and the person so designated. This does not imply that the choice of symbols is completely arbitrary; probably it is determined by little known psychological principles.

Furthermore, a symbol connotes or represents a certain content and thus is different from language as expression or as command found also among animals. A bird's song expresses and communicates to its mate a certain physiological and, we may be sure, psychological state, but it does not connote a thing. The barking of a dog warns of some danger, but it does not indicate whether the source is an intruding burglar or the neighbor's cat.

Finally, symbolism and language are defined as being transmitted by learning and tradition. For example, the language of the bees, admirably described by von Frisch, is representative. By means of intricate dances, the workers communicate to their colleagues the direction and distance of the place where food may be found. But this language is innate and instinctive. We can teach a dog all sorts of tricks, but we have never heard that a particularly clever dog has taught its puppies to do them.

Not being an anthropologist, I do not venture a hypothesis on the origins of symbolism and human language. I have a strong suspicion, however, that they might be found in imitation and magic.

For primitive man, an image, be it material or acoustical, is the original and gives him control and dominance over it. This is the essence of sympathetic magic. Think of a very primitive and common form of magic. A puppet made from clay *is* the enemy, and the enemy can be killed if a needle is thrust into the image. When the paleolithic hunters painted those grandiose frescoes of deer and lions on the walls of caves in France and Spain, we may be sure that it was not just *l'art pour l'art*; but rather a powerful charm for successful hunting.

The same applies to an acoustical or onomatopoetic image. By naming things, man takes possession of the world in their symbolic images. For this reason, Adam's first work in paradise was to give names to animals, plants, and things. Naming a thing gives power over it. In contradistinction, Yahwe's name is unspeakable. For if His name should be uttered, He would be submitted to the will of him who knows it. The sorcerer evokes the demons of hell by calling their names.

Hence, the assumption that the origin of human language was in verbal magic does not seem to be far-fetched. A sound uttered may give some onomatopoetic image of an animal or person or may be connected with some biological function. For example, the word for *mother* begins in nearly all languages, irrespective of their structure, with an *m* (after Kluckhohn), apparently a sound connected with the smacking by the baby at the mother's breast. Thus a sound may become an image of a thing. Consequently, the sound will be identified with the original just as the clay image is identified with the enemy, and then uttering the sound will govern the thing designated. Thus, language may be born of magic, a process certainly infinitesimally slow in its beginnings, but man has had many hundred thousands of years at his disposal to come from an anthropoid to *Pithecanthropus, Sinanthropus,* and *Homo sapiens.*

Whatever the origin of symbolism, its consequences are enormous. The first consequence is obvious. Phylogenetic evolution, based on hereditary changes, is supplanted by history, based on the tradition of symbols. In the biological sphere progress is possible only within an evolutionary timescale. For example, the societies of ants have remained unchanged for the past 50 million years. In contrast, human history has a time-scale of generations, comprising almost all high cultures in a span of 5000 years, and it may even be thought that cultural time has a logarithmic, rather than an arithmetic, scale with changes taking place at an ever-increasing pace.

Second, corporeal trial and error as found in subhuman nature is replaced by reasoning — that is, trial and error in conceptual symbols. An animal placed into a maze, faced with a complicated lock or confronted with some other problem, runs around until it finds the way out. It tries until the mechanism of opening the door or the solution of the problem is discovered by chance. Then the way leading to success is gradually fixed. Man in a corresponding situation sits down and thinks; that is, he experiments not with the things themselves but with the symbolic images of things. He scans different possibilities, discounts those that seem ineffective without laboring to try them materially, and accepts the apparently successful solution as the basis for overt behavior. The interpretation of thought processes as substitutes for experimental actions was maintained by Freud (*14*).

A third and more profound consequence of symbolism is that it makes true purposiveness possible. Purposiveness in a metaphorical sense —

that is, regulation of function in the way of maintenance, establishment, and reestablishment of organic order — is a general characteristic of life. It is based on such principles as equifinality of the steady state of the organism, homeostatic feedback mechanisms, learning by trial and error and conditioned reflex, selection in evolution, and so forth. But even in the most amazing phenomena of regulation and instinct we have no justification for and definite reasons against the assumption that these actions are carried through with foresight of the goal. This true or Aristotelian purposiveness is unique to human behavior and is based on the fact that the future goal is anticipated in thought and determines actual behavior.

When man passed the stage of barbarism, he had to realize that verbal magic was impotent. Thrusting needles into the enemy's image did not as a rule kill him. Similarly, a name is just a label attached to a thing and not the thing itself. It is true enough that relics of primeval verbal magic are still with us, much more than is desirable. In speaking of a "nation," "state," or "party," we behave as if those names were things, whereas actually they denote personificative fictions, hypostatizing groups of individuals with their egoistic interests, little intelligence, and exaggerated passions for mythical entities.

If verbal magic was deceptive, another sort of symbolic magic was discovered that was extremely powerful. We may call it the magic of the algorithm.

An algorithm is a system of symbols connected according to preestablished rules. Take the simplest example, the name of whose propagator, al-Khowarizmi, is immortalized in this word. This is the decimal notation. In Roman numbers even a trivial multiplication, such as LXXVI × XCIII, is quite a formidable operation. However, the simple trick that the last digit of a number in Arabic notation means units, the second tens, and so on, and that corresponding figures are written in columns makes the operation child's play. Thus an algorithm means a machine of thinking, performing operations by suitable connections of symbols, and giving results difficult to attain or unattainable otherwise. Or, conversely, calculating and thinking machines, mechanical or electronic, are only the materialization of algorithms. Algorithmic magic is commonly known as science and scientific technology.

So long as symbols stand alone they are unproductive and do not convey more information than that contained in the individual symbols. Thus in the flag-language used by seafarers each flag symbolizes a certain fact or command, but an array of flags is just the sum of the individual meanings.

This is profoundly altered if symbols are combined according to established rules of the game, if they are elements in an algorithm or, as we may say, if a language has not only a "vocabulary" but also a "grammar." Then the system of symbols becomes productive and fertile. With a suitable choice of terms and of rules presupposed, we can handle the symbols as if they were the things they represent. If the symbols, as well as the grammar, are well chosen, the result of the mental operation of symbols will correspond to that of the real course of events. The consequences of the images will be the images of the consequences, to use Heinrich Hertz' expression.

In this way a true magic is possible with systems of symbols. We can predict facts and relationships still unknown, can control still unrealized combinations of natural forces, and so on.

Science, to a large extent, consists in the invention, elaboration, and application of suitable algorithms. Trivially the algorithm of physics is mathematics in the ordinary sense. But the language of, say, chemical formulas or of genetics also represents algorithms suitable for the particular realm. The same is true even if the system is remote from what is ordinarily called mathematics, as is the Linnean system of classification. With its binary nomenclature, the classification of organisms into species, genera, families, classes, and so forth, is also an algorithm symbolically representing certain aspects of reality — the manifoldness of, and relationships between, animal and plant forms, allowing to a certain extent for scientific prediction.

The universe of symbols, although created by man, wins a life of its own, as it were. The development of the Roman law, the British Empire, the atomic theory from Democritus to Heisenberg, or of music from Palestrina to Wagner, is certainly borne by a number of human individuals. But it shows an immanent logic that widely transcends the petty personalities, the human and all-too-human creators.

This autonomous life of the symbolic world has a most important positive aspect. The symbolic universe becomes, so to speak, more clever than man, its creator. Thus the symbolic system of language, and particularly of the artificial languages called mathematics and science, develops into a colossal thinking machine. An operational command, a hypothesis with the necessary specifications, is fed in; the machine starts to run and eventually by virtue of preestablished rules of the connection of symbols, a solution drops out which was unforeseeable in the individual mind with its limited capacity. This is the general characteristic of scientific reasoning, be it a simple arithmetic operation or the solution of a differential equation, the prediction of still undiscovered planets and chemical elements, or the construction of some masterpiece of modern technology.

Besides these triumphs of symbolism, there are, however, its pitfalls. The conceptual anticipation of future events that allows for true purposiveness is at the same time the origin of anxiety in regard to the future and fear of death, which is unknown to brutes. The invention of the symbolic world is the fall of man. The notions of sin and evil arise with the invention of symbolic labels attached to certain forms of behavior. War also is a human invention. It is not a biological phenomenon, the continuation of the omnipresent biological struggle for existence. Even if nature were "red in tooth and claw," which it is only to a limited extent, organized intraspecific warfare would still be unknown in the subhuman world. Apart from the rather rational strifes of savages who go out and kill enemies in order to eat them, war is caused by head hunting, illusions of grandeur, ideologies, economic reasons based upon symbol-charged values, religion — all of them only superficially different kinds of verbal magic. This, however, leads to the ingratiating conclusion that war is not a biological necessity and that it would not be unavoidable if mankind would put its symbolic abilities to better use.

If there is a clash between the symbolic world built up as moral values and social conventions on the one hand, and basic biological drives on the other, then, with respect to the individual, the situation of neurosis arises. Somewhat extending the narrower definition of Freud, it seems that a neurotic situation results from the conflict of a symbolic universe with biological drives, or of opposing symbolic worlds. As a social force the universe of symbols, which is unique in man, creates the sanguinary course of history. Thus man has to pay for the uniqueness that distinguishes him from other beings. The tree of knowledge is the tree of death.

Although I have tried to indicate some biological bases of human behavior, it is impossible to give more than a few glimpses of this tremendous problem here. I have not even mentioned many equally important fields, such as genetics with the question of inheritance of behavioral, mental, and psychopathological traits; nature and nurture; race; ecology with its applications to human populations; the Malthusian problem; the question of providing for an ever-growing humanity; the evolution of animal behavior from unconditional to conditional reflex, instinctive action, and insight and its bearing on human behavior; and many others. In some way or another, it seems that behavioral science is supposed to contribute to the pressing problems of our epoch, not only in the way we invent nice little theories, mathematical models, and so forth, but also in the critical state that the social organism seems to be in at the present time.

REVOLT OF THE MASSES

The basic symptom of present society seems to be the uprise of the masses or the proletariat, as is depicted so vividly by authors like Ortega y Gasset and Toynbee. Let us forget for the present discussion about the demographic aspects, the increasing overpopulation of our planet, and the Malthusian threat and concentrate on the behavioral aspect. I believe that a precise answer to the problem can be given in biological terms.

I am inclined to define the "revolt of the masses" as a return to the conditioned reflex. The unique characteristic of human behavior is the ability to make decisions at a symbolic level. This, of course, does not mean that conditioned behavior is negligible. Any human achievement, from toilet training to speech, driving a car, or learning calculus and theoretical physics, is based on conditioning. However, the dignity of man rests on rational behavior — that is, behavior directed by symbolic anticipation of a goal. In modern man, however, this *vis a fronte*, to use Aristotle's term, consisting of goals the individual or the society sets itself, is largely replaced by the primitive *vis a tergo* of conditional reaction.

The modern methods of propaganda, from the advertisement of a tooth paste to that of political programs and systems, do not appeal to rationality in man but rather force upon him certain ways of behavior by means of a continuous repetition of stimuli coupled with emotional rewards or punishments. This method is essentially the same as that applied to Pavlovian dogs when they were drilled to respond to a meaningless stimulus with reactions prescribed by the experimenter. Not that this method is new in human history. What is new, however, is that it is applied scientifically and consistently and so has an unprecedented power. The modern media of mass communication, newspapers, radio, television, and so on, are able to establish this psychological constraint almost without interruption in time, reaching all individuals in space with maximum efficiency. If a slogan, however insipid, is repeated a sufficient number of times and is emotionally coupled with the promise of a reward or the menace of punishment, it is nearly unavoidable that the human animal establishes the conditioned reaction as desired. Furthermore, to apply this method successfully, the conditioning process must be adjusted to the greatest common denominator; that is, the appeal has to be made to the lowest intelligence level. The result is mass-man — that is, abolishment of individual discrimination and decision and its replacement by universal conditioned reflexes. *Brave New World* and *1984* are but paraphrases of this theme.

Obviously there is no easy solution to the problem, and it is wise not to join the quacks who have found the wonder drug to cure the ills and entanglements of humanity. However, precisely because of the predominance of psychological techniques, realization of the motive forces of human behavior becomes the more important. Herein lies the responsibility of the science of human behavior. Besides the menace of physical technology, the dangers of psychological technology are often overlooked. Perhaps even more dangerous than the material existence of the bombs are the psychological forces that may lead to the dropping of them. As we try to put atomic energy to peaceful use, it may even be more urgent to put to intelligent use the psychological mechanisms revealed by behavioral science (15).

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Speech and Thought

SIR RUSSELL BRAIN

As the reader may have noticed in other selections in this book, British scientists are not so troubled with the concepts of *mind* and *mental functions* as psychologists in the United States are likely to be. To Sir Russell Brain, the task of psychology is to contribute an understanding of the workings of the mind, then add that to what physiologists and neurologists learn about the nervous system. In another view, psychologists, wishing to understand behavior, try to assess the role of biological systems as contributing variables and as responding mechanisms. From this point of view there is no need to assume the existence of mental elements at all. Physiological and psychological functions can be observed, comprehended, and ordered into a systematic understanding of natural phenomena. Whether or not mentalistic forces exist seems to be a question which lies outside the realm of scientific psychology. The author of this selection presents some highly interesting facts about brain functions and how they may be related to behavior, as well as to what he calls "mind."

Sir Russell Brain is past president of the Royal College of Physicians and author of several important books in neurology. The selection which follows was originally presented as one of a series of talks on the BBC Third Programme. It was reprinted as Chapter 6 in *The Physical Basis of Mind*, edited by Peter Laslett and published in 1952 by Basil Blackwell. It is reprinted by permission of the publisher.

I am going to talk about speech and thought. I want to begin by telling you something about what happens in the brain when we speak, and then go on to discuss what light that throws upon what happens when we think. Professor Adrian said in his talk how difficult it is from the standpoint of *physiology* to conceive of a way to bridge the gulf between the brain and the mind, and he pointed out that we must look for progress in psychology to help us towards a solution of the problem. It is a parallel advance in physiology and psychology that we need, and in this talk I am going to try and show where I think that advance is likely to occur — in fact, where it has already begun.

I want to attempt to answer this question — are there functions of the nervous system which are at the same time both physiological and psychological? I don't mean by this occurrences like the electrical changes which can be detected in the back of the brain when we see, for since we do not know the connection between the electrical changes and seeing, they take us no further. But, are there events in the brain which we can understand as being at the same time both physiological and mental? Now I believe that there are, and it is in the realm of speech and thought that we shall find them, even though at the moment they are little more than dim outlines seen through the mist of our ignorance.

As we all know, speech has two sides to it; we listen to speech and we speak ourselves. I shall not have time to say anything about the second aspect of speech, which consists of the utterance of words: I shall have to confine myself to what has been called the receptive side; that is, the understanding of words which we hear and read. This element in speech seems, in fact, to be more closely related to thinking than the means by which we express our thoughts when we have already arrived at them.

I am speaking to you now, and you are listening to me. No doubt it seems to you a very simple process, but, in fact, it is so extremely complicated that it is very difficult to understand. Let us take as an example the word "dog." I pronounce the word in one way and you may pronounce it in another. If I were born in Devonshire and you were born in Glasgow, or Bradford, there would be considerable differences in the way in which we should speak, and yet we should understand one another. No two people pronounce the word "dog" in exactly the same way, yet we always know what it means. Not only that, but I might sing it, or shout it, or whisper it, and it would still convey the same thing to you. The puzzle arises from the fact that each different way of pronouncing "dog" causes a different electrical disturbance in the nervous system. High-pitched notes go to one spot on the surface of the brain and low-pitched notes go to another which, though not far away, is quite distinct. So if your voice is high-pitched you will start electrical currents moving in one place in my brain, and if it is low-pitched in another, and every variation in the inflection of your voice will produce a different electrical disturbance in the brain of the hearer. And yet he will always hear and understand the same word.

But we can go further than that. Suppose that I had lost my voice and had to write the word "dog" and show it to you. It will still *mean* the same thing to you though the word no longer consists of sounds, but is made up of black marks on a white piece of paper; you will still be able to understand it, whether it is written or printed, in large or small letters, in black or coloured type, and in any sort of handwriting short of complete illegibility: in many handwritings the marks that people make on the paper have very little resemblance to the letters they are supposed to represent. Here, then, there is as great a variety among the visual patterns presented to the nervous system as among spoken words. Moreover, the patterns of things we see send electrical impulses to a different part of the brain from that which is concerned with hearing. The brain's quite separate centers for the sense of touch can also be brought in. If you can read braille, you will be able to recognize a series of raised pimples on the paper, which make a pattern quite unlike ordinary letters, and yet also mean the word "dog."

Now we know that in the brain there is a complicated set of nervous pathways, like a whole series of electrical circuits, which are thrown into activity whenever we think of the meaning of the word "dog"; and there are different sets of nervous pathways for other words. The problem, therefore, is to explain how a single set of pathways, those concerned with the meaning of the word "dog," can be selected from all the others and set going by any one of that indefinitely large number of different groups of sounds and patterns on paper which constitute all the possible ways of saying, or writing, or printing the word so that it can be understood. When I dial an automatic telephone exchange I ask it a question to which I hope to receive an accurate answer, namely, the subscriber to whom I wish to speak, but the machine is very particular about the way in which I put the question. If I want Whitehall 1212, I must dial WHI 1212 and nothing else. No machine has been designed which will answer with Whitehall 1212 if I or anyone else *speak* the words and figures into the mouthpiece. Only the human brain can do this. Until the dialling machine was designed to standardize the way the question is asked, the human brain of the telephone operator had to be employed at the exchange. Now I do not think it is theoretically impossible to design a machine which could answer fairly accurately to the spoken voice, but I suspect that if it ever is made it will have to embody the same principles upon which the human brain works.

Perhaps, after all, the automatic telephone does provide a clue to what happens in the brain. What the dialling apparatus does is to convert the letters and figures of the telephone number into a certain pattern of electrical impulses in time and space, which is different for each number. What the brain does with the spoken word — and no one can say how it does it — is to extract from it an electrical pattern in time and space which is distinctive of the word "dog," and common to all the ways in which it can be pronounced, so as to be recognized. It is as though the meaning of the word were locked up in a cupboard which had to be opened by a key. The curious thing is that it is possible to open it by a very large number of keys which superficially seem to be very different from one another. But what makes a key open a lock is a certain kind of pattern. The pattern of the key must be appropriate to the pattern of the lock, and if it is appropriate it does not matter whether the key is made of brass, or steel, or silver, or even gold. In the brain the patterns are very complicated electrical ones. All the possible ways of pronouncing the word "dog" so that it can be understood have something in common; that is, a certain pattern of sound. This in turn is capable of exciting in the nervous system its own particular pattern of nervous circuits, and this constitutes the key that unlocks the door which contains the meaning of the word. In somewhat the same way all the different ways of writing or printing the word "dog" arouse a common pattern in a different part of the brain and this also fits the lock of the meaning.

All this complex process goes on in our brains without our knowing anything about it. We hear or read the word and we know what it means, but we know nothing at first hand about the processes which form the link between the two. Sometimes we lose the key either temporarily or, as a result of disease, permanently. You have forgotton someone's name: let us suppose it is "Johnson": I ask you if it is Smith, Brown, or Robinson, and you reject all these. "Is it Johnson?" I say, and you say at once, "Yes, that is it!" When you did not know what the name was, how did you know it was not Smith, Brown, or Robinson? Because these keys did not fit the lock, and when I offered you Johnson it fitted and at once you realized that that was the key you had lost. This illustrates the point that there are processes in the recognition of words of which we are not conscious. What I have called the lock must be unconscious, for you used the Johnson lock to test the key, yet your possession of the lock did not by itself enable you to remember the name.

Now let us turn to thought and consider an abstract idea: let us choose the idea of triangularity. A rat can be trained to recognize a triangle and distinguish it from a square or a circle; such a rat may be said to be aware of triangularity. The process in the nervous system by means of which a rat recognizes a triangle is of the same kind as that by which a human being recognizes a word. The pattern of excitement aroused in the rat's nervous system by all sorts of triangles has something in common which is distinct from that aroused by other geometrical figures, and this common pattern influences the rat's behavior.

It would be possible to teach a child to recognize a triangle in the same way as a rat is taught. A child might be shown a variety of figures and given a chocolate when it chose a triangle and a punishment when it chose anything else. But since we can speak to a child we can take a short cut and say, "A triangle is a figure bounded by three straight lines." We shall then have to use words to enable the child to grasp an abstract idea. But we must not forget that someone must have had the idea of a triangle before it could be described in words. So speech and thought interact. If we are to name something, the nervous system must be capable of recognizing a common pattern in a number of different objects; and, when an object has already been named, this in itself helps us to detect what it has in common with other objects of the same name. We can get along very well in simple matters without using words for our thinking, but as soon as we have to think about things which are not concrete objects we find it difficult to think without words. If you go into a room and find the cat on the table drinking milk, you take in the situation and act appropriately without formulating, even in your own mind, the words "cat," "table," and "milk," though you would have to do so if you wanted to draw the attention of someone else to what was happening. But listen to this sentence from Plato: 'Can there be any greater evil in the state than discord and distraction and plurality where unity ought to reign?' We cannot think about the ideas contained in that sentence without using words for the purposes of our thought.

I have spoken earlier about the meaning of a word. Without going into the much-debated philosophical question of the meaning of meaning I want to point out that we use the term meaning in at least two different ways Let us take as an example a proper name — 'St. Paul's Cathedral.' In one sense these words mean — that is, they refer to — a certain building in London. But in another sense, when I say that I know what they mean I am saying that they enable me to think of that building, and what I think of it will depend upon my past experience of it. If I have seen it I shall perhaps form a mental picture of its dome rising above London. If not, I may think of a service broadcast from it, or of Harrison Ainsworth's novel, *Old St. Paul's*, or of the cathedral of which John Donne was dean. Any or all of these are, as we put it, what St. Paul's Cathedral means to me. So in this sense the meaning of a word implies its power to awaken in us all kinds of past associations, ideas and feelings, and sometimes memory-images, and these must depend upon numerous and widespread pathways irradiating over the surface and deep into the substance of the brain. Yet clearly we can speak the word and know what it means without calling up any of these associations, so that often in conversation the words 'St. Paul's Cathedral' just stand for all these potential associations without necessarily making us conscious of any of them. We are able to do this because there exists in the brain an electrical pattern for each word which is not identical with those underlying either its sound or its meaning.

Here we have reached the foundation of all language — the fact that a word can stand for the concrete thing or the abstract idea which it represents. But the value — and also the danger — of words for the purposes of thought is that though they are linked with their meanings we can deal with them as though they were relatively independent of them. We treat them as counters, or bank-notes, or cheques, so that, as the philosopher Leibniz put it, we can perform complicated operations with them and wait until these operations are concluded before converting the results into coins. But words would be useless for thinking if they did not retain below the surface of our minds their links with their meanings; and it was the constant task of Socrates, as it is of philosophers to-day, to persuade people to examine the meanings of the words they use.

Now let me try and sum up what I have said. All stimuli, whether sights, sounds, or other sensations, reach the brain as electrical patterns, and it seems to be a basic function of the nervous system to analyse these patterns so as to detect similarity amidst differences. A rat can distinguish a triangle from other geometrical figures, and this is the beginning of abstract thought. We do the same thing with words. The word 'dog' for the nervous system is not simply any of the thousand and one ways in which it can be pronounced: it is also an electrical pattern which is called up by each and all of them and of which we are not even conscious. The function of this electrical pattern is to arouse other patterns — those underlying ideas, feelings, and perhaps memory-images, which is what the word means to us and through which we know what it refers to. We can think to some extent without words, but only in rather a concrete way: we cannot entertain abstract ideas without using them. But when we think with words we often use them, like counters, to stand for things or ideas, in order to save ourselves the trouble of having to think every time about the things or ideas themselves. To that extent we are all like the little girl who was told to think before she spoke and replied: 'But how can I know what I think till I hear what I say?'

Is it likely that physiology will ever throw any real light upon the relationship between the brain and the mind? I believe that, working in conjunction with psychology, it will; but you must not expect me to give you a clear idea of how that will happen. I can only guess where present advances seem to be leading us. Think of a pattern. An atom is a pattern of electrons, a molecule is a pattern of atoms. There are patterns of patterns of patterns, and so on indefinitely. The most complicated patterns we know are in the brain. Not only are there twelve thousand million nerve cells out of which the patterns can be made, but nervous patterns exist in time, like a melody, as well as in space. If you look at a tapestry through a magnifying glass you will see the individual threads but not the pattern: if you stand away from it you will see the pattern but not the threads. My guess is that in the nervous system we are looking at the threads while with the mind we perceive the patterns, and that one day we shall discover how the patterns are made out of the threads.

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The Physical Basis of Mind: A Philosopher's Symposium

A. J. AYER

At the conclusion of the series of BBC broadcast talks which included selection 45, there was a symposium discussion in which three noted British philosophers participated. This selection is the summation and critique by one of them. It was chosen because of the telling manner in which the author neatly and sharply points up the dilemma of looking for mental functions within physiological tissue. In doing this, he lets us in on a bit of the logic which must support any scientific explanation and shows why we must be particularly careful that our logic is sound when we apply thought to the process of thinking. Ayer warns against considering mind as immaterial substance, but he feels that there are two ways of describing experience.

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I wonder if Lord Samuel has made it completely clear exactly what the problem is that the philosophers are here called upon to solve? The scientists who have spoken in this series have shown very fully and convincingly how various mental processes — thinking, feeling, perceiving, remembering — are causally dependent upon processes in the brain, but to some of them at least the character of this connection still appears mysterious. Thus, Sir Charles Sherrington remarks that 'it is a far cry from an electrical reaction in the brain to suddenly seeing the world around one, with all its distances, colours, and chiaroscuro'; and Professor Adrian confesses to the same 'misgivings' when he says that 'the part of the picture of the brain which may always be missing is of course the part which deals with the mind, the part which ought to explain how a particular pattern of nerve impulses can produce an idea; or the other way round, how a thought can decide which nerve cells are to come into action.'

If this is a genuine problem, it is hard to see why further information about the brain should be expected to solve it. For however much we amplify our picture of the brain, it remains still a picture of something physical, and it is just the question how anything physical can interact with something that is not that is supposed to constitute our difficulty. If what we are seeking is a bridge across a seemingly impassable river it will not help us merely to elevate one of the banks. It looks, indeed, as if some of the previous speakers were hoping to discover in the brain something describable as the locus of the mind; as if mind and brain could be conceived as meeting at a point in space or as somehow shading into one another: but to me this is not even an intelligible hypothesis. What would it be like to come upon this junction? By what signs would you recognize it if you found it? Descartes had the same problem, and he met it by suggesting that mind and body came together in the pineal gland; but how this conjecture could conceivably be tested he did not explain. The reason he had the problem — the reason why we have it still — is that matter and mind were conceived by him from the outset as distinct orders of being; it is as if there were two separate worlds, such that every event had to belong to one or other of them, but no event could belong to both. But from these premisses it follows necessarily that there can be no bridge or junction; for what would the bridge consist of? Any event that you discovered would have to fall on one or other side of it. So, if there is a difficulty here, it is not because our factual information is scanty, but because our logic is defective. Perhaps this whole manner of conceiving the distinction between mind and matter is at fault. In short, our problem is not scientific but philosophical.

Let us consider, then, what can be meant by saying that a particular pattern of nerve impulses 'produces' an idea, or that 'a thought decides' which nerve cells are to come into action. What are the facts on which such assertions are based? The facts are that the physiologist makes certain observations, and that these observations fall into different categories. On the one hand there are the observations which lead him to tell his story about nerve cells and electrical impulses. That is to say, the story is an interpretation of the observations in question. On the other hand there are the observations which he interprets by saying that the subject of his experiment is in such and such a 'mental' state, that he is thinking, or resolving to perform some action, or feeling some sensation, or whatever it may be. It is then found to be the case that these two sorts of observations can be correlated with one another; that whenever an observation of the first type can be made, there is good reason to suppose that an observation of the second type can be made also. For example, when the scientists make observations which they interpret by saying that such and such nerve cells are undergoing such and such electrical disturbances, they can also make observations which are interpreted by saying that the subject is having sensations of a certain type. Again, when they are able to make such observations as are interpreted by saying that the subject is resolving to perform some action, they can also make further observations which are interpreted by saying that certain impulses are passing through certain of his nerve fibres. It seems to me that when it is asserted that the two events in question — the mental and the physical — are causally connected, that the pattern of nerve impulses 'produces' the sensation, or that the thought 'decides' which nerve cells are to operate, all that is meant, or at least all that can properly be meant, is that these two sets of observations are correlated in the way that I have described. But if this is so, where is the difficulty? There is nothing especially mysterious about the fact that two different sets of observations are correlated; that, given the appropriate conditions, they habitually accompany one another. You may say that this fact requires an explanation; but such an explanation could only be some theory from which the fact of this correlation could be deduced. And in so far as the theory was not a mere redescription of the facts which it was intended to explain, it would serve only to fit them into a wider context. We should learn from it that not only were these observations correlated, but certain further types of observation were correlated with them. To ask *why* something occurs, if it is not simply equivalent to asking *how* it occurs, is to ask what other things are associated with it. Once the facts are fully described, there is no mystery left.

If there seems to be a mystery in this case, it is because we are misled by our conceptual systems; not by the facts themselves but by the pictures which we use to interpret the facts. The physiologist's story is complete in itself. The characters that figure in it are nerve cells, electrical impulses, and so forth. It has no place for an entirely different cast, of sensations, thoughts, feelings, and the other *personae* of the mental play. And just because it has no place for them they do not intervene in it. The muddle arises from trying to make them intervene, as I am afraid Lord Samuel does. We then get a confused, indeed an unintelligible, story of electrical impulses being transmuted into sensations, or of mental processes interleaved with disturbances of the nervous cells. The picture we are given is that of messengers travelling through the brain, reaching a mysterious entity called the mind, receiving orders from it, and then travelling on. But since the mind has no position in space — it is by definition not the sort of thing that can have a position in space — it does not literally make sense to talk of physical signals reaching it; nor are there such temporal gaps in the procession of nervous impulses as would leave room for the mental characters to intervene. In short, the two stories will not mix. It is like trying to play *Hamlet*, not without the Prince of Denmark, but with Pericles, the Prince of Tyre. But to say that the two stories will not mix is not to say that either of them is superfluous. Each is an interpretation of certain phenomena and they are connected by the fact that, in certain conditions, when one of them is true, the other is true also.

My conclusion is, then, that mind and body are not to be conceived as two disparate entities between which we have to make, or find, some sort of amphibious bridge, but that talking about minds and talking about bodies are different ways of classifying and interpreting our experiences. I do not say that this procedure does not give rise to serious philosophical problems; how, for example, to analyse statements about the thoughts and feelings of others; or how far statements about people's so-called mental processes are equivalent to statements about their observable behaviour. But once we are freed from the Cartesian fallacy of regarding minds as immaterial substances, I do not think that the discovery of causal connections between what we choose to describe respectively as mental and physical occurrences implies anything by which we need to be perplexed.

47

Neurology and the Mind-Brain Problem

R. W. SPERRY

Probably every curious, intelligent person at some time has wondered about the relationship or connection between physiological functions in his brain and those thoughts, feelings, and sensations which he has learned to call "the content of consciousness." With their different methods and points of view, philosophers, psychologists, and certain of the biologists have also attempted to solve this riddle, but without notable success. Brain (selection 45) felt that the secret could somehow be solved by pushing our knowledge of patterns of nerve impulses in brain tissue. Ayer (selection 46) felt that we must restructure the logic with which we approached the problem. Sperry proposes still another solution — one that is attractive to many physiological psychologists. He examines, but then discards, theories of specific nerve qualities, sensory fields, and timing and coding of impulses. The thesis he constructs and defends is one which considers the brain a kind of transformer between input of sensory information and output of motor activity. The products of the brain are not ideas, thoughts, and the like, but muscle actions. The brain process is an adjustment to a stimulus, not a reduplication or a representation of it. Sperry's position is a modern form of what was once known as the motor theory of consciousness. This selection is somewhat more difficult than others in this book, and should be read after the student has mastered the fundamentals of the operation of the nervous system.

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The discrepancy between physiological processes in the brain and the correlated psychic experiences to which they give rise in consciousness has ever posed a baffling puzzle to students of psychology, neurology, and the related sciences. Despite steady advancement in our knowledge of the brain, the intrinsic nature of mind and its relation to cerebral excitation remains as much an enigma today as it was a hundred years ago.

Interest in the problem of the mind-brain relationship extends far beyond the immediate concerns of neurology and psychology. Inability to comprehend the essence of mind has been a major obstacle to the progress of philosophy throughout its history. Questions such as those concerning scientific truth, the nature of reality, and the place of man in the cosmos require for their study some knowledge of the constitution, quality, capacities, and limitations of the human mind, through which medium all such problems must be handled. Much of man's religious dogma and his moral and even legal codes is deeply influenced in the final analysis by mind-matter concepts. In fact, all the ultimate aims and values of mankind could be profoundly affected by a thoroughgoing rational insight into the mind-body relationship. It was the broad significance of the problem as much as the difficulty of reaching a solution that prompted William James (*1*) to declare that the attainment of a genuine glimpse into the mind-brain relation would constitute "*the* scientific achievement before which all past achievements would pale."

The struggles of philosophy with psychophysical problems, although carried on over centuries and by some of the greatest thinkers in history, have as yet failed to produce anything of much satisfaction to the tough-minded scientist. Further progress from philosophical synthesis can be expected only after science has succeeded in furnishing philosophy additional data with which to work. For example, we shall be in a much better position to study mind-brain relations after we have attained some conception of the neural patterning involved even in such simple mental activities as the perception of color, time, pattern, size, and the like. Eventually it should be possible to list the special features which distinguish those brain excitations that are accompanied by consciousness from those that are not. Once this latter objective is achieved, it may be feasible, at last, to attack the mind-body problem with some effectiveness.

It is really the "brain" part of the mind-brain relation that most urgently needs clarification. Neurological science thus far has been quite unable to furnish an adequate description of the neural processes involved in even the very simplest forms of mental activity. Once the unknown neural events become sufficiently understood, it may be found that the mind-brain problem will tend to resolve itself. In any case, hope for progress now seems to lie entirely in this direction.

Accordingly we may by-pass many blind alleys of philosophical controversy, and turn immediately to the neural correlates of conscious experience. In the following discussion we shall be concerned principally with the nature of the neural processes themselves, keeping in mind questions such as the following: How do the brain patterns of visual sensation, for example, differ essentially from those of auditory or other modes of sensation? How does the pattern of brain excitation in the visual perception of a triangle differ from the excitation involved in perceiving a square or a circle? And so on. Thus, we propose to deal primarily with definite scientific questions subject to objective scientific answers in neurological terms.

CURRENT STATUS OF THE PSYCHONEURAL DILEMMA

Any immediate attempt to relate brain processes to psychic experience appears rather discouraging. To provide the colorful richness and infinite variation of quality and meaning in mental experience we find only a mass of brain tissue consisting essentially of closely packed nerve fibres and cell units roughly similar to one another in constitution, in structure, and in the physiological functions they perform. Such variation in size, shape, chemistry, conduction speed, excitation threshold, and the like, as has been demonstrated in nerve cells remains negligible in significance for any possible correlation with the manifold dimensions of mental experience.

Near the turn of the century it was suggested by Hering *(2)* that different qualities of sensation, such as pain, taste, and color, along with other mental attributes, might be correlated with the discharge of specific modes of nervous energy. Electronic methods of recording and analyzing nerve potentials, developed subsequently, have however failed to reveal any such qualitative diversity. It has been possible to demonstrate by other methods a refined constitutional specificity among neuron types *(3, 4)*. However, proof is lacking that this specificity influences in any manner the quality of impulse conduction. It seems rather to be operative primarily in the developmental patterning of the neural circuits. Although qualitative variance among nerve energies has never been rigidly disproved, the doctrine has been generally abandoned on a number of grounds in favor of the opposing view, namely, that nerve impulses are essentially homogeneous in quality and are transmitted as "common currency" throughout the nervous system.

Impulses traveling in the optic, auditory, proprioceptive, and other sensory pathways are, accordingly, believed to be similar in nature. "It is not the quality of the sensory nerve impulses that determines their diverse conscious properties but rather the different areas of the brain into which they discharge." This is the current point of view, and it seems to be warranted. When an electric stimulus is applied to a given sensory field of the cerebral cortex in a conscious human subject, it produces a sensation of the appropriate modality for that particular locus, that is, a visual sensation from the visual cortex, an auditory sensation from the auditory cortex, and so on (5). When one looks for intrinsic differences in the matrix of these sensory fields that might account for qualitative psychic differences, there is disappointingly little to be found. Slight variations in the size, number, arrangement, and interconnections of the nerve cells have been demonstrated, but as far as psychoneural correlations are concerned, the more obvious similarities of these sensory fields to each other and to all other cortical fields, including the association and motor areas, seem much more remarkable than are any of the minute differences. Furthermore, sensations as diverse as those of red, black, green, and white, or of touch, cold, warmth, movement, pain, posture, and pressure apparently may arise through activation of the same cortical areas. For these and other reasons the reference of subjective quality to cortical locus, in itself, has little explanatory value. What seems to remain is some kind of differential patterning effects in the brain excitation. We may state, rather vaguely, that it is the difference in the central distribution of impulses that counts.

In short, current brain theory encourages us to try to correlate our subjective psychic experience with the activity of relatively homogeneous nerve-cell units conducting essentially homogeneous impulses through roughly homogeneous cerebral tissue. To match the multiple dimensions of mental experience we can only point to a limitless variation in the spatiotemporal patterning of nerve impulses. The difference between one mental state and another is accordingly believed to depend upon variance in the timing and distribution of nerve excitations, not upon differences in quality among the individual impulses.

On the foregoing points there is comparative agreement (6, 7, 8). When we proceed to the question of exactly how conscious meaning is related to the spatiotemporal patterning of brain excitation, all certainty is lost and we enter an area of free speculation. The oldest, simplest, and still the most common notion on this matter holds that brain patterns resemble in form, and in a sense copy in miniature, outside objects and those of consciousness. For example, in the visual perception of a simple geometric figure like a triangle, the brain pattern is considered to be, at least roughly and with certain qualifications, triangular in form. This doctrine, formally called *psychoneural isomorphism* (9), has been extended to correlations in intensity, and in temporal organization as well as in spatial patterning. It appears to receive some direct support in the anatomical evidence that the sensory surfaces, such as the retina, skin, cochlea, and so on, are in fact projected onto the brain centers according to an orderly topographic plan.

In a corollary of this hypothesis adopted particularly by the Gestalt school of psychology (*9, 10, 11, 12*) it is contended that subjective experience is not correlated with the orthodox neural excitations traveling along fiber pathways, as commonly supposed, but rather with secondary electrical fields and currents which these excitations create in the brain tissue. The secondary electrical patterns, with their "field forces," are conceived to be massive and to spread through and between the nerve cells and fibers, pervading the cerebral tissue as a volume conductor. Unlike the scattered array of separated impulses from which they are generated, these mass patterns are unified and continuous in nature and therefore more like the patterns of subjective experience. This added correspondence in continuity and unity, along with the postulated similarities in form, intensity, and temporal patterning already mentioned, is believed to alleviate the discrepancy between neural and psychic processes.

Isomorphism, as has been stated by Boring (6), represents the most natural and naïve way of dealing with mind-brain relations. It is implied unintentionally in a great deal of scientific as well as lay thinking about brain function, especially where perception, imagery, or memory is involved. For example, the neuroanatomist unwittingly works on this premise when he searches the brain for fiber pathways to unite the two halves of the visual field, which — inconveniently for the concept of isomorphism — are projected separately to opposite hemispheres of the cerebral cortex.

When the philosophic and logical basis of isomorphism is examined, its seeming metaphysical solace tends to dissolve, and it becomes difficult to see how anything is gained by having the neural processes copy the contents of consciousness. Furthermore, recent experiments designed specifically to test the importance of the postulated field forces in cerebral organization have failed to disclose any significant influence of such factors (*13, 14*). Finally, it seems to me that our general knowledge of brain structure and physiology has for many years been quite sufficient to rule out any possibility that cerebral processes duplicate, even remotely, the patterns of subjective experience. This point is amplified in some detail below.

Other current theories of perception based more closely on the classical concepts of brain physiology ignore or deny any need for psychoneural isomorphism. In an effort to account for the retention of perceptual habits following destruction of major portions of the brain areas involved in learning. Lashley (*15*) has suggested that incoming sensory excitations may spread outwardly in waves that travel along the homogeneous fiber feltwork of the cortex. These spreading waves are presumed to set up widespread interference patterns such that any visual figure — a triangle, for example — becomes translated in the brain into a multi-reduplicated "scotch-plaid" type of pattern extending over the entire cortical area. All correspondence in shape with the original figure is lost in the reduplicated brain patterns.

Another hypothesis which has been proposed to account for our knowledge of universals and the perception of auditory and visual forms (*16*) postulates a scanning function to the alpha brain rhythm, which, as it passes up and down through the successive layers of the cortex, is supposed to bring about an enlargement and reduction inversely of the incoming sensory patterns. The authors of this theory expressly deny that the spatiotemporal distribution of brain excitations representing a given figure need resemble the actual figure in any simple way.

A third, rather different picture of the perceptual process is proposed by Hebb (*17*). Convinced that visual perception occurs beyond the sensory receiving area of the cortex, he has attempted to follow the sensory pattern deeper into the brain. The type of excitation process arrived at, although vague in actual detail, retains even less resemblance to the original stimulus pattern than in the two foregoing theories.

In these and other hypotheses of perception it is assumed, in opposition to the tenets of isomorphism that sensory stimuli become transformed in the brain into patterns of excitation that need not resemble in any way either the original stimulus or the contents of consciousness. The brain is presumed to work with a kind of code of its own in which the symbols bear no direct correspondence to the mental experiences they represent.

With the doctrine of psychoneural isomorphism rejected along with that of specific nerve energies, some such codal scheme has seemed to be the only remaining alternative. The problem is thereby reduced to that of discovering the correct nature of a brain code based on the patterning of homogeneous nerve impulses. Even these restrictions have continued to leave a wide range for speculation. Advancements in neurology and psychology in the past several decades have tended progressively to limit this range, but its boundaries have again been widened of late by contributions from the field of computing-machine and signal engineering. Again one can find estimations of the contents of consciousness based on the total number of possible combinations and permutations of neuron elements. Other writers would code mental information into individual neurons, and still others into their protein molecules. The scope and diversity of opinion to be found in the current literature reflect our general confusion and almost complete lack of guiding principles.

Whereas the doctrine of psychoneural isomorphism has purported to bridge the mind-brain gap through principles of similarity and correspondence, the various "coding" schemes leave one with no basis whatever for resolving the problem. Even the most neurologically sophisticated of these latter hypotheses, as now stated, seem only to exaggerate rather than to minimize the mind-brain dichotomy. Perhaps as a hangover from early behaviorism, many investigators have continued to pride themselves on a deliberate policy of ignoring entirely any questions that touch upon the relation of subjective experience and neural activity.

The following comment of Charles Sherrington (*18*) remains as valid today as when he wrote it more than eighteen years ago: "We have to regard the relation of mind to brain as still not merely unsolved, but still devoid of a basis for its very beginning." It is not a solution we aspire to but only a basis on which to begin.

A DIFFERENT APPROACH TO THE PROBLEM

A tentative attempt is made in the following discussion to point out and to justify another approach to the interpretation and understanding of mental activity. So far, only the vague outlines of the scheme are discernible. Even these outlines, however, if they could be verified, would help considerably to orient our efforts and would automatically eliminate much misguided speculation.

The proposed scheme rests on a view of brain function which was most nearly approximated in the old motor theory of thought, now largely abandoned. Despite its recognized shortcomings and errors, this forsaken offspring of behaviorism taken in combination with the pragmatism of C. S. Pierce (*19*) possibly holds the key to a comprehension of brain function far advanced beyond anything developed subsequently. An analysis of our current thinking will show that it tends to suffer generally from a failure to view mental activities in their proper relation, or even in any relation, to motor behavior. The remedy lies in further insight into the relationship between the sensori-associative functions of the brain on the one hand and its motor activity on the other. In order to achieve this insight, our present one-sided preoccupation with the sensory avenues to the study of mental processes will need to be supplemented by increased attention to the motor patterns, and especially to what can be inferred from these regarding the nature of the associative and sensory functions. In a machine, the output is usually more revealing of the internal organization than is the input. Similarly in the case of our thinking apparatus an examination of its terminal operations and finished products may be more enlightening than any amount of analysis of the transport of raw materials into it.

Only after we have attained some understanding of the way in which the sensory and thought processes become transformed into motor activity, can we hope to comprehend their meaning and plan of organization. Only then can valid working principles be found to curb and to guide future theorizing.

Utilization of this motor approach immediately helps us to view the brain objectively for what it is, namely, a mechanism for governing motor activity. Its primary function is essentially the transforming of sensory patterns into patterns of motor coordination. Herein lies a fundamental basis for the interpretation, direct or indirect, of all higher brain processes including the mental functions. At first thought such statements will probably seem most short-sighted and unsatisfactory. Nevertheless, for purposes of scientific analysis, a perspective of this kind seems necessary, and we may turn now to an attempt to justify it.

Partial support is found in phylogenetic considerations which indicate that the vertebrate brain was designed primitively for the regulation of overt behavior rather than for mental performance. As one descends the vertebrate scale, purely mental activity becomes increasingly insignificant compared with overt response. Among the salamanders and lower fishes, where thought processes are presumably negligible, the bulk of the nervous apparatus is clearly concerned with the management of motor activity. To the extent that sensation and perception are evident, these would appear to serve directly for the guidance of response. From the fishes to man there is apparent only a gradual refinement and elaboration of brain mechanisms with nowhere any radical alteration of the fundamental operating principles. In man as in the salamander the primary business of the brain continues to be the governing, directly or indirectly, of overt behavior.

Overt behavior, upon analysis, we find to be constituted almost entirely of patterns of muscular contraction. It follows that the principal function of the nervous system is the coordinated innervation of the musculature. Its fundamental anatomical plan and working principles are understandable only on these terms.

Further support for this point of view may be found in the study of brain architecture. One searches the cerebrum in vain for any structures that seem to be designed for the purpose of forming, cataloguing, storing, or emanating copies or representations of the outside world (see p. 258). If any scheme or plan at all is evident in the complicated fiber associations and nuclear interconnections of the brain, it is a design patterned throughout for governing excitation of the "final common (motor) pathways." Such information as is now available regarding physiological functions of the various brain centers correlates with the anatomical data to support the same thesis.

To the neurologist, regarding the brain from an objective, analytical standpoint, it is readily apparent that the sole product of brain function is motor coordination. To repeat: the entire output of our thinking machine consists of nothing but patterns of motor coordination. The neurohumoral and glandular components may be disregarded in this discussion. We may also disregard the various by-products of brain activity such as heat, electric potentials, carbon dioxide, and other metabolites released into the blood stream, cerebrospinal fluid, and surrounding tissues.

This classification of the electric potentials as an irrelevant by-product rather than an important end-product of brain activity requires some comment, inasmuch as certain authors have considered these to be the essential correlates of consciousness. It is well established that brain activity generates electrical currents and potential changes which vary greatly in rate and amplitude. These phenomena extend well beyond the confines of the brain and may be recorded readily at the surface of the scalp. It would be difficult or impossible at this point to furnish irrefutable proof that the manufacture of these electrical changes is not a major object of cerebral activity. However, many reasons for doubting it, both direct and implied, will be found throughout the present discussion.

In our scheme these stray mass potentials have no more special function or meaning than have the similar electrical currents that pervade the entire body whenever the heart beats, muscles contract, and so on. There is no evidence that they react back upon the processes that produce them nor otherwise influence these processes in any significant fashion. Brain organization, we suspect, is maintained in spite of these secondary electrical effects, not because of them. In a conscious patient with brain exposed under local anaesthesia it should not be difficult to pass electric currents through a sensory field of the cortex during perceptual tests. We would anticipate no functional disturbance provided the currents were maintained within the normal physiological limits. In so far as electrical changes do operate directly in the conduction of nerve impulses, synaptic transmission, maintenance of excitatory thresholds, and so forth, they constitute an essential part of the brain function itself and are not to be classed as one of its end-products.

The layman naturally assumes the major work of the brain to be the manufacture of ideas, sensations, images, and feelings, the storage of memories, and the like, and often expects the physical correlates of these to be some kind of aural end-product phosphorescing within the cortex or emanating from its convolutions. These subjective phenomena may, however, be regarded as phases of brain function itself, not products of it. Scientific analysis has failed to disclose any output at the cerebral level other than the miscellaneous by-products mentioned above. Excepting these, the entire activity of the brain, so far as science can determine, yields nothing but motor adjustment. The only significant energy outlet and the only means of expression are over the motor pathways.

Thus, whether accompanied by consciousness or not, all brain excitation has ultimately but one end, to aid in the regulation of motor coordination. Its patterning is determined throughout on this principle. It follows that efforts to discover the neural correlates of consciousness will be more successful when directed on this basis than when guided by arbitrary correlations with psychic experience, stimulus patterns, or outside reality, or by analogies with various types of thinking machines.

The above approach to mental functions may require some shift in our customary perspective on the interrelation of cerebral and motor processes. Instead of regarding motor activity as being subsidiary, that is, something to carry out, serve, and satisfy the demands of the higher centers, we reverse this tendency and look upon the mental activity as only a means to an end, where the end is better regulation of overt response. Cerebration, essentially, serves to bring into motor behavior additional refinement, increased direction toward distant, future goals, and greater over-all adaptiveness and survival value. The evolutionary increase in man's capacity for perception, feeling, ideation, imagination, and the like, may be regarded, not so much as an end in itself, as something that has enabled us to behave, to act, more wisely and efficiently.

Perceptions and ideas are found, upon analysis, to have their factual significance and meaning in terms ultimately of overt operation. Their meaning derives from the potential effect, that is, the difference they make or may make in behavior. In both its phylogenetic and ontogenetic histories, mental activity develops out of, and in reference to, overt action.

Actually the interrelation of motor and mental activity is one of cyclic and reciprocal interdependence. However, the nature of the problem and current trends in our thinking make it necessary at this time to emphasize particularly the dependence of the mental upon motor activity.

Any separation of mental and motor processes in the brain would seem to be arbitrary and indefinite. Mental processes are intimately associated with other integrative mechanisms which we are accustomed to recognize as serving for the regulation of motor adjustment. Sensory and associative processes, conscious and unconscious alike, are obliged to merge and interlace in the brain with the motor patterns. There are no boundary planes in the cerebrum to keep the two apart. In many or most situations overt response is guided closely and directly by the excitation patterns of thought and perception. Temporally, therefore, as well as spatially, the mental and the motor patterns must integrate, mesh, and interlock.

The same relationship is indicated in more specific anatomical and physiological observations. The great pyramidal motor pathway from the cerebral cortex is constituted of fibers which arise from many cortical areas, sensory as well as motor. Motor responses may be elicited directly by electrical stimulation of sensory areas, as, for example, the visual and the somesthetic cortex. The extrapyramidal motor outflow from the cerebral cortex likewise arises from associative and sensory cortical fields as well as from those traditionally designated as motor. Excitation patterns in the sensory and associative areas, therefore, have to integrate with patterns in the subcortical motor systems as well as with those in neighboring motor fields.

In brief, we conclude that the unknown cerebral events in psychic experience must necessarily involve excitation patterns so designed that they intermesh in intimate fashion with the motor and premotor patterns. Once this relationship is recognized as a necessary feature of the neural correlates of psychic experience, we can automatically exclude numerous forms of brain code which otherwise might seem reasonable but which fail to meet this criterion.

It follows further that the more we learn about the motor and premotor mechanisms, the more restrictions we add to our working picture of the unknown mental patterns and hence the closer our speculation will be forced to converge toward an accurate description of their true nature.

IMPLICATIONS FOR A THEORY OF PERCEPTION

Past theory and speculation concerning the neural correlates of subjective experience have been based to a large extent upon phenomena of visual pattern perception. For the sake of comparison some further implications of the present thesis may also be illustrated most effectively with reference to the same material. Consider the cerebral excitations which take place, for example, during the visual perception of a simple geometric figure, say a triangle. Of what exactly does the brain process consist, and how is it patterned?

A satisfactory explanation of the neural events involved in this one simple example of visual perception would carry us a long way toward an understanding of cerebral organization and mind-brain relations in general. Several possible types of answer as suggested in isomorphic theory and in other recent theories of perception have already been mentioned above.

By comparison, one arrives at a quite different kind of picture by utilizing the approach advocated earlier in this paper (pp. 251–252). This approach does not lead us to expect in the cerebral process any kind of triangularity, linearity, nor even a unity corresponding to that of the perceived triangle. Nor are we led to seek any kind of codal representation of these. What we are prompted to search for, primarily, is an excitation process so patterned as to bring about a central adjustment that will put the premotor and motor systems into readiness for adaptive response to the given triangle. Reasoning on this principle from the motor mechanism backward, step by step, into the association and sensory centers, one is able to construct a working picture of the brain pattern which, although necessarily vague in the present state of our knowledge, differs significantly in principle from anything obtained by tracing the retinal triangle centralward or by attempts to translate the subjective triangle directly into neural patterns.

If there be any objectively demonstrable fact about perception that indicates the nature of the neural process involved, it is the following: In so far as an organism perceives a given object, it is prepared to respond with reference to it. This preparation-to-respond is absent in an organism that has failed to perceive. In the case of the triangle, a person who perceives it, is ready to point to it, to outline it with his finger, to show its location and orientation in space, to pick it up, describe it, etc. Animals lacking the verbal and symbolic capacities of man illustrate the principle more simply. The perceiving animal is able to avoid or to approach the triangle, to run under it or up one edge of it, to leap to a corner of it or to pick it up in its mouth by one of the points, etc. The presence or absence of adaptive reaction potentialities of this sort, ready to discharge into motor patterns, makes the difference between perceiving and not perceiving.

The preparation-to-respond in perception is a demonstrable fact. All that need be questioned is whether it may not be a consequence of, rather than a part of, the cerebral process which actually constitutes the perception itself. In this regard we may emphasize again that the structure of the brain, as well as what is known of its physiology, discourages any effort to separate the motor from the sensory and associative processes. To the best of our knowledge there is only a gradual merging and transformation of the one into the other, with nothing to suggest where perception might end and motor processes begin. That the preparation for response *is* the perception is suggested by further considerations.

Perception is not correlated with the immediate arrival of stimulus patterns in the sensory receiving areas of the cortex. Compare two persons gazing at the same visual field in which lies a triangle, with only one of them perceiving the triangle. (Failure to perceive elements of the visual field is common enough with respect to ordinary scenes or pictures but is more strikingly illustrated in the case of hidden figures in picture puzzles, *trompe-l'oeil* paintings, ink blots, etc.) In both persons the retinal pattern and its transmission into the visual receiving areas of the brain are essentially identical. Therefore, the mere transmission of sensory patterns into the visual cortex does not, in itself, constitute perception nor is it sufficient to bring it about. This is also suggested in the fact that many of our perceptions involve the combined influence of afferent patterns from more than one sense modality. In the case of vision, postural and kinesthetic factors are regularly involved along with the retinal cues in determining the spatial orientation and stability of "visual" perception. Since these different afferent influences are projected to separate cortical fields, the combined perceptual effect must lie deeper.

Perception is more than the mere passage of sensory patterns into passive brain protoplasm. In the nonperceiving subject the stimulus pattern of the hidden figure may pour into the brain for seconds or even minutes, producing widespread secondary and tertiary effects throughout the nervous system, without the figure's being seen. Something else is needed, something that approaches an active and specific adjustment on the part of the brain.

This fact is indicated in our ability to see the same stair diagram as if from above or below, or a cube diagram with first one corner extending toward us and then another. The stimulus pattern during the perceptual shift remains constant, as does its projection into the brain. The perceptual shifts must therefore depend on active changes within the brain itself. It should be noted also that these perceptual shifts involve changes in the tendency to respond. When one corner of the cube is nearest, we are ready to react to the cube, to reach for it, handle it, deal with it in these terms. When the other corner seems nearest, our reaction tendencies shift accordingly.

Many other examples can be cited to illustrate the same fact, namely, that perception is basically an implicit preparation to respond. Its function is to prepare the organism for adaptive action. The problem of what occurs in the brain during perception can be attacked much more effectively once this basic principle is recognized.

It follows that it will be necessary to learn something about the nature of those central integrative mechanisms that lead into motor adjustment before we can picture in any detail the neural processes of perception or of other mental activities. Knowledge of the stimulus pattern and its projection into the cerebral cortex is not enough. The patterning of the perceptual process is determined as much by the organization of the central mechanisms as it is by the sensory influx. This is evident in the general tendency to perceive selectively what one is already looking for and expects to see. Carried further this may lead to visual illusions or, in the extreme, to hallucinations. In the latter case, almost the entire organization is determined centrally. Hallucinations constitute further evidence that the psychic experience is not correlated with the discharge of the retinal image into the visual cortex, but depends on subsequent and more complex operations.

It is common to think of visual hallucinations and visual imagery as dependent on some kind of central rearousal of an essentially sensory pattern. In the case of the visual image of a triangle, for example, we might postulate a re-excitement in the visual cortex of a triangle or whatever coded pattern — according to our favored theory of perception — the sensory stimulus is presumed to establish there. This would demand the dispatch from somewhere in the centers of an array of discharges patterned somewhat like the original sensory influx. It is difficult to see how such a pattern could be dispatched from anywhere other than from the retina itself. This difficulty is not encountered when we conceive of perception as an incipient preparation for action, with the brain excitation taking the form of a central adjustment leading into response to the figure. Rearousal of this type of pattern from central sources is neurologically feasible.

ISOMORPHISM AND TOPOGRAPHIC PROJECTION IN SENSORY PATHWAYS

The rejection of isomorphism obliges us to find another explanation of the orderly topographic projection of sensory surfaces in the brain. Actually, further thought on the problem will reveal that an orderly anatomical projection fails anyway, under most conditions, to insure even a rough similarity between the brain pattern and that of the perceived figure. To illustrate, consider further the visual perception of a triangle. The brain pattern, in the first place, is split in two because the two halves of the visual field are projected to opposite hemispheres of the brain. The two halves are not neatly drawn apart with a gap between them, but instead the mid-plane of each is reflected laterally away from the other. This is the primitive condition; in man the mid-planes tend to be twisted posteriorly. Although fiber pathways that would serve to unify the visual areas of the two hemispheres have been sought, none has been found.

The triangular pattern is equally divided in the cortex only while the gaze is perfectly centered in the mid-plane of the figure. When the fixation point shifts to either side, the fragments of the triangle projected to each hemisphere change accordingly. As the eyes rove over the triangle from apex to base and from side to side, the shape and also the position of the cortical patterns change radically in each hemisphere. One can compare the effect photographically to a series of multiple exposures of various fragments of a triangle flashed successively with erratic shifting of the center of the figure in each hemisphere.

While this kaleidoscopic series of excitatory changes is taking place in the visual cortex of the brain, the figure of subjective experience remains constant, a unified whole, with a fixed orientation in space. If exactly the same retinal projection patterns were produced, not through eye and head movements but by actual movement of the figure itself while the gaze is kept fixed (as might be done with cinema projection methods), the subjective effect would, of course, be entirely different. With the projection to the visual cortex identical in each instance, the difference in "visual" sensation must be attributed to the difference in the proprioceptive influx from the eye muscles. The importance of proprioception in vision is only mentioned in passing because it illustrates further the impossibility of correlating perceptual experience with the immediate projection of the retinal image to the sensory cortex, as well as the lack of similarity between the form of the perceived triangle and that of the excitatory process in the brain.

Additional dissimilarity is caused by the enlarged cortical representation of the macula of the retina (*20*). The portion of the figure that falls on the macular area becomes magnified in the brain relative to the rest of the triangle. The resultant warping differs from moment to moment with each change of fixation. And, of course, the flat two-dimensional triangle becomes irregularly folded and twisted when projected upon the fissures and convolutions of the cortex. These latter spatial distortions also are subject to variation with each shift of fixation.

In summary, the topographic projection of the retina upon the cerebral cortex fails to insure any significant similarity in form between the figure of perceptual experience and that of the brain excitations. The possibility of psychoneural isomorphism is even more remote with respect to the other senses. Consider, for example, stereognosis and the perception of the three-dimensional form of a triangular block of wood placed in the hands. The cutaneous discharges projected to the cortex from the palms of the hands and the moving fingers as they explore the surface contours, already lacking any resemblance to triangularity, must further be integrated and interpreted at each instant with reference to the train of postural and kinesthetic cues entering from each of the many moving joints. The result is a brain process the configuration of which is hopelessly removed from that of the object perceived.

Topographic projection is explainable on other bases than that of mediating isomorphic representation. It is significant that the same type of fiber projection is found in the motor and associative parts of the brain and also in nonspatial sensory systems like that of smell and possibly taste. Certainly topographic projection is quite comprehensible as a reflection of the developmental processes of neurogenesis (3, 4) and would seem to be a simple framework on which to build more refined structural organization.

If topographic projection could be eliminated by random displacement of the nerve cell bodies, at the same time maintaining all the original synaptic connections and conduction-time intervals, complete functional disorganization should follow according to isomorphic field theory. On the other hand, little or no disturbance would be expected from the standpoint of orthodox circuit theory.

IMPRESSED SENSORY PATTERNS VERSUS OPERATIONAL ADJUSTMENT

The major fluctuations in the excitation patterns of the visual cortex caused by ocular movements in perception are accompanied by simultaneous shifts in the nonvisual kinesthetic influx. These two inputs integrate with activity already going on in the brain centers to produce a relatively stable over-all adjustment to the perceived triangle. The constancy of the subjective experience derives, not from any constancy in the sensory patterns impressed on the cortex, but from the integrative effect of their more central resultant. This does not mean that the subjective constancy depends strictly upon the excitation of a final invariant group or pattern of central neurons. It is the functional, or operational, effect of the input patterns upon the dynamics of cerebral adjustment that counts. The over-all adjustment might have a constant functional or subjective value even though the particular neurons excited and the spatial and temporal patterning were to vary from experience to experience or to fluctuate radically during a single perceptual span. Waning in one part of the pattern, for example, might be compensated by increased intensity in another, or by the entry of new excitatory elements, to preserve the over-all effect.

It must be emphasized that the constancy and other subjective properties of the brain process are not to be evaluated in terms of sensory geometry or of even a closely related frame of reference as is our usual inclination. An entirely new frame of reference applies, one that is based ultimately on motor adjustment.

We may arrive at a better conception of the neural events in visual perception if we imagine our sample triangle as being constructed gradually in time out of dots and dashes that are passed successively into the brain to produce each its individual vertical effect. This may seem contradictory to demonstrated Gestalt principles in perception but actually it is contradictory only to some of the secondary inferences drawn therefrom regarding brain physiology. It is well established by tachistoscopic studies that a complicated pattern is not perceived in full detail with the initial projection of the pattern into the brain. The total picture comes gradually; at first the broader and bolder features are seen and then, by steps, further details. The perception of simultaneous *spatial* relations thus commonly depends upon *temporal* organization in the brain processes.

Consider the neural adjustments involved in perceiving a single dot on the wall before you. The stream of impulses entering the midbrain and cortex will first set up responses that tend to center the eye on the dot. This may involve head as well as eye movements and possibly the entire musculature. Immediately with perception of the dot comes readiness to locate it and to respond to it. Widespread facilitating and inhibiting effects are invoked in many parts of the brain. The cerebral mechanisms have become set for a certain class of reactions. This particular set will automatically exclude an infinite number of other reaction possibilities. Probably your eyes will not remain fixed upon the dot but will stray around the wall in its vicinity. As a result the stream of excitations in the brain will drift about the visual cortex. Nevertheless the dot appears to stay fixed meanwhile, and you remain oriented with reference to it.

Now suppose another dot is added in the neighborhood of the first. This sets up another stream of impulses which in turn arouses responses somewhat similar to those of the first dot. The adjustments from the first largely remain, however, and essentially the result is an additional adjustment superimposed upon the first.

The addition of a third dot sets up other reactions that further modify the adjustments already present. There are now three streams of impulses passing through the striate cortex. As the eyes move about from one dot to another and to neighboring points on the wall, the spatial patterning of the three streams of impulses through the cortex varies greatly. Not only do the three foci of excitation flash about in different positions in the cortical field, but the number projected in each hemisphere will fluctuate from none to three. The simultaneous spatial interrelationships thus undergo continuous variation in the cortex so that it is impossible to think of any type of horizontal "field" force binding these streams of impulses together in the constant pattern that is perceived.

To the three dots may be added two more, and so on. Then the dots can be closed gradually by dashes and more dots until the triangle is completed. The cerebral adjustment to a single dot meanwhile will have been built upon and modified into an adjustment to respond to a partial and finally a whole triangle. The sensory input must be pictured throughout as influencing and modifying premotor and motor patterns of excitation that are already present. One may say that the sensory input is perceived and acquires conscious meaning only in so far as it modifies preceding patterns of central activity. The foregoing approach to the perceptual process is suggested merely to aid in visualizing the neural events as an active meaningful adjustment, rather than as simply an impression or passive registration in brain tissue of a pattern of sensory excitation.

By the same procedure one might build a square or a hexagon. Although the first several dots in each case might be identical and arouse the same response, the final adjustment will differ according to the pattern completed. As emphasized by the Gestalt school, it is the over-all pattern that counts, both in the perceived figure and in the brain process; but this is no reason for inferring isomorphic correspondence between the two, nor for assuming that it is the secondary mass electrical disturbances that constitute the important phase of the brain process.

UNITY, NUMBER, AND SIZE IN PSYCHONEURAL CORRELATION

When a visual figure is perceived as a unified whole, it is natural to suppose that the brain pattern also possesses a corresponding unity. In theories of the codal as well as of the isomorphic type a given unit in brain process is commonly supposed to represent a given unit of psychic experience.

We must, however, ask in what manner the brain process, as in the perception of a triangle, should be unified. Must the discharging neurons be side by side, unseparated by resting or inhibited cells? Or is it enough if their fiber processes link with one another? Or perhaps it is only the electric potentials they generate that must meet or overlap? Reference has been made above to the suggestion that conscious experience is correlated with secondary electrical changes that are massive, field-like, and continuous in nature. These very properties which would appear to preserve physiological unity, however, would at the same time seem to preclude any finely etched perceptual effects involving thin lines, abrupt contrasts, and sharp boundaries. The concept also fails to account for the unity of the visual scene, the projection of which is split in half in the cortex with the mid-lines directed outwardly and posteriorly. Discovery of duplicate projections of the retina via the pulvinar, colliculus, and so on, will hardly simplify matters. Actually we have yet to find any satisfactory criterion of unity in the neural processes that can account for the unity in psychic experience.

In the scheme proposed here it is contended that unity in subjective experience does not derive from any kind of parallel unity in the brain processes. Conscious unity is conceived rather as a functional or operational derivative. In perception it means only that the brain becomes adjusted to deal with the perceived object as a unit. There need be little or nothing of a unitary nature about the physiological processes themselves. The essential parts of the preparation-for-response may be rather widespread through the brain with nowhere a compact unified pattern of discharge that represents "triangle." The retention of perceptual and other habits following extensive brain lesions (*15*) and the seeming "equipotentiality" of cortical areas become less difficult to account for with such a concept of cerebral organization.

Closely related to the problem of unity is that of number. Consider the perception of two, three, or more triangles present in the visual field simultaneously. The brain process might be pictured as a corresponding number of excitation patterns each representing "triangle," in either isomorphic or signal-code terms. Actually, in the cerebral preparation for response to a number of items there is no need for a corresponding number of unitary excitation processes. Three triangles viewed simultaneously tend to be perceived together as one larger unit. The extent to which this unification occurs will vary, of course, with many factors, but in any case the brain process will not be found to be anything like a mere tripling of that which occurs in the perceiving of a single triangle. Consider the motor patterns involved in handling one tennis ball compared with those used in handling three tennis balls — or to be consistent, make it triangular blocks instead of spheres. A comparison of these motor processes at the cerebral level, even though vague, will be more suggestive of the principles or neural patterning involved in perceiving groups of items than will inferences based on attempts to trace the stimulus figures centralward.

The same principles apply to the perception of size. Compare the brain processes involved in perceiving a large and a small triangle. Are we to infer that the two are similar except that the former is larger? According to our present thesis there need be little or no correlation between the size of an object in perception and the size of the correlated brain pattern. The adjustment of the brain to deal with a large triangle will differ in certain respects, but it need not cover a larger volume of cerebral tissue. The nature of the differences is perhaps better indicated again by comparing the motor patterns involved in handling a small and a large triangular block. The motor-pool discharge in the two cases will differ with respect to timing and intensity in an extremely complex fashion but the size of the triangles is not reflected in any direct way in the extensity of the central excitations. This applies as well to the premotor firing and to all excitation following the initial sensory projection into the brain.

SENSORY EQUIVALENCE

Sensory equivalence is illustrated in the ability of an animal to recognize and to respond similarly to patterns of the same configuration even though these differ markedly in size from the one used in training. It has been almost universally inferred that some kind of brain mechanism is needed such that the equivalent sensory patterns, after filtering through the cerebral cortex, become funneled in one way or another into a given invariant central excitation regardless of their starting size and position at the sensory surface. Similar reasoning has been applied to problems of generalization and abstraction.

According to our present scheme, brain function is not organized on these principles at all. Psychic meaning is not so direct a reflection of corresponding properties in the brain mechanisms. Subjective meaning depends on the over-all *functional* effects of the physiological processes, not upon their copying or representing in code form the attributes of the stimulus. Further, the brain process must be viewed basically as an *adjustment to* a perceived or imagined item, not a reduplication or representation of it.

The "equivalent" responses of the rat to a large and to a smaller triangle, for example, whether it be jumping at doors or selecting alleys, may have little in common as far as the physiological details of the motor discharge are concerned. The same is true of the more central or perceptual part of the brain process. It is only in the over-all functional or operational effect that their essential similarity resides. In the centers as well as at the sensory surfaces the patterning counts. In the centers, however, it is not a copy-type or geometrical kind of pattern that is involved, but a much more intricate one fashioned in accordance with the complex web of brain pathways and designed to work through this medium into motor adjustment. The central excitation may vary considerably in its geometric, spatiotemporal, and other properties while maintaining invariant or equivalent functional value as measured with reference to motor adjustment. In other words the same functional effect and the same psychic meaning *may* be obtained from brain patterns the neuronal details of which differ considerably on different occasions. Not only may different neurons be involved, as many configurationists would agree, but more than this, the configuration of neurons may vary.

In the above examples, the visual perception of a triangle is assumed to be built up in the nervous system as an active operational adjustment that puts the brain in readiness to respond to the triangle. Although the general adjustment may involve actual motor changes, the core of the perceptual process in the higher centers is not itself a motor pattern. It is more premotor or better pre-premotor in nature, owing to the hierarchical plan of neural organization. This continued emphasis on the motor approach to mental activity should definitely not be taken to imply that subjective experience resides within any motor reaction or within the motor system. If obliged to localize the conscious experience, we could only suggest vaguely those brain centers midway functionally between the sensory input and motor output, where the coordinated action of the entire motor system may be governed as an integrated whole through the combined influences of most of the sensory excitations and mnemonic traces. This vital focus of neural organization might possibly be centered in the brain stem primarily, as suggested in the observations of Bailey (*21*), Penfield (*5*), and others, rather than in the cerebral cortex itself.

It has been indicated repeatedly that the brain excitation is neither a copy nor a codal representation of subjective experience. Psychic meaning is presumed to be intrinsic in the brain organization itself, such that once the brain patterns are fully understood, no additional "key" should be necessary to interpret the subjective meaning.

Much of what has been said above with reference to pattern perception applies to other forms of mental activity. Thinking itself may be regarded as a prolongation and elaboration of perception embodying additional factors such as insight, trial-and-error processes, reasoning, and especially the use of symbols. Essentially it is implicit, symbolic preparatory adjustment without commitment in overt action. The cerebral excitations are presumed to be patterned throughout with ultimate — but not necessarily direct — reference to the motor and premotor systems. This holds even where the thought process is entirely symbolic. In the person "thinking out loud," in whom we get some indication of the nature of the inner activity, it is noteworthy that the overflow into the motor periphery is clearly of such pattern as to effect coordinated innervation of the musculature.

Perhaps the mental experiences most difficult to account for in the terms proposed here are the immediate sensory qualities. We have no satisfactory explanation of these on any basis as yet, and it is not easy at present to see how the conscious qualities of sensation relate to their operational effects in the motor system. Of all psychic functions, the sensations are farthest removed from the motor side. They are genetically predetermined and involve a detector and discriminatory type of cerebral adjustment that has little direct commitment in motor activity.

Particularly in the case of sensory qualities it is tempting to have recourse to some form of specific nerve energies. For the present, however, it would seem more fruitful to assume that the difference between, for example, taste and tactile sensations does not derive from any difference in the quality of the individual impulses but rather from differences in the way in which the two afferent systems are linked into the central organization, and from the differential dynamic effects thereby secured. That the sensations have emerged in the course of evolution as attributes of mere complexity alone in neural organization seems less likely than that each sense modality depends upon a specific design the meaning of which may become apparent once the neurological analysis is carried far enough. Sensations certainly appear to function directly in the guidance and control of motor adjustment, and we can only hope that when the sensory regulation of motor coordination becomes more thoroughly understood, it will be possible to see where the sensory qualities fit into the rest of the scheme.

One need not feel distressed at the suggestion that all our noblest and most aesthetic psychic experiences may be found, on analysis, to consist merely of brain patterns designed, directly or indirectly, for the adjustment of muscular contraction and glandular secretion. This detracts nothing from their meaning and importance. In the same way our finest deeds consist only of patterns of muscle-fiber twitches, our greatest printed passages only of ink marks on paper, while our most ravishing music, as pointed out by William James, is but the rasping of hairs from a horse's tail on the intestines of a cat. Significance and meaning in brain function do not derive from the intrinsic protoplasmic or other analytic aspects of neural excitation, but rather from their higher-order functional and operational effects as these work upon successive brain states, upon the motor system, and thereby into the environment, and back into the brain. We should not expect to find that a single neuron or an isolated patch of neurons, or even a cortical center, could sense, feel, experience, or think anything in isolation. These psychic properties we envisage as depending upon a specific design and complexity in the vortex of neural activity, generally involving a reciprocal interplay of many parts.

It will be evident that our scheme leaves much unanswered. It is inevitable that the reader, like the writer, will find it wanting and unsatisfactory in many respects. At best it can only be offered tentatively as a possible basis on which to begin to describe the neural events of mental experience.

SUMMARY

At the core of all metaphysical problems stands the mind-brain relationship, real understanding of which could have vast influence on all the ultimate aims and values of mankind. The logical, philosophic, and semantic approaches to the question, though employed intensively by some of the greatest of human minds, have repeatedly failed to yield a satisfactory resolution of the problem. Hope for further progress is seen to lie in a scientific analysis of the neural correlates of psychic experience, and the present discussion has been restricted primarily to this essentially neurological problem.

Present-day science is quite at a loss even to begin to describe the neural events involved in the simplest forms of mental activity. Conjecture has been vague and varied, ranging from theories in which the brain patterns are supposed to parallel and to copy roughly the contents of consciousness, to a series of codal schemes in which psychic experience is represented by implication in various brain codes with no other meaningful psychoneural relation indicated.

An approach to the interpretation of higher brain functions is here suggested in which motor adjustment, rather than stimulus patterns or the contents of subjective experience, figures predominantly as a proper frame of reference for understanding the organization, meaning, and significance of brain excitation. Such an approach would seem to guarantee at least a better understanding of the brain processes themselves. Whether this in turn may help to resolve the baffling mind-brain enigma remains to be seen.

ACKNOWLEDGMENT

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Self-Regulatory Behavior After Extirpation of Certain Endocrine Glands: A Review

FRANK B. STRANGE

Although the principle was recognized for a long time, it was Cannon who, in 1939, showed that physiological functions of the body are self-regulatory, and it was Cannon who proposed and popularized the term "homeostasis." Dr. Strange reviews research to show that in the absence of those glands which are instrumental in the maintenance of balance, an animal will modify its behavior to preserve the necessary internal constancy. For example, animals increased their nest building activity, thus preserving body heat, to maintain constancy under abnormal conditions. From the work of Curt P. Richter, the psychophysiologist, and others, Strange shows how the behavior of organisms is sometimes activated by internal conditions. In the first part of a later selection a more detailed account is given of the principles of homeostasis.

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In recent years much attention has been directed toward the self-regulatory functions of the body. Probably the most outstanding worker in this area has been Walter B. Cannon, who suggested the term "homeostasis" to signify the constant conditions maintained by the body, conditions which may vary but which are relatively constant. Although the term is new, Cannon points out that the ability of living beings to maintain their own constancy has long impressed biologists, and he lists several scientists who have given expression to this thought: Hippocrates (460–377 B.C.), Pflüger (1877), Leon Fredericq (1885), and Charles Richet (1900). Cannon has directed his research in this matter, as summarized in *The Wisdom of the Body* (1), mainly to study of the relation of the autonomic system to the self-regulation of physiological processes.

Another investigator who has contributed to the knowledge of self-regulatory functions is Curt P. Richter, who has approached the field in a different manner, through the study of endocrine glands. Writing in 1941 (2), Richter pointed out that only recently was it realized that the ability of animals to satisfy internal needs under a great variety of normal and pathological conditions by appropriate activity could be understood in terms of a broad biological concept first stated in 1859 by Claude Bernard — the concept of constant internal environment. Richter indicated that Bernard and Cannon have laid stress upon some of the single factors which help to maintain a constant internal environment. "In addition," he states, "we believe that the ability of animals to maintain a constant internal environment, after certain single organs or physiological regulators have been removed, clearly establishes the existence of behavior or total organism regulators (2).

It is the purpose here to review research related to the self-regulatory behavior of animals following removal of certain endocrine glands. Since the great majority of research in this area has utilized the rat as the experimental animal, and for the sake of unity, only experiments using the rat will be reported. Studies concerned with the following will be considered: (*a*) the relationship between aspects of behavior and body temperature following hypophysectomy; (*b*) the relationship between aspects of behavior and water balance after extirpation of the posterior lobe of the pituitary; (*c*) the relationship between aspects of behavior and the sodium concentration of the blood following adrenalectomy; (*d*) the relationship between aspects of behavior and the calcium concentration of the blood after parathyroidectomy; (*e*) the relationship between aspects of behavior and diabetic symptoms following pancreatectomy.

BODY TEMPERATURE

The chief regulators of body temperature are the thyroid and the anterior lobe of the pituitary. Death will result within a few days if animals from which either of these glands has been removed remain in even slightly lowered external temperature (2). Kinder (3) has reported that nest building is inversely related to environmental temperature. Animals that were given access to paper used little and made small and loosely constructed nests at room temperature. Nest building activity was greatly increased as was the quality of nest construction when the temperature was lowered. The behavior of the rats served apparently to maintain a constant body temperature.

Employing a modification of cages used earlier by himself (4) and by Kinder for studying nest building in the rat, Richter (5) found that hypophysectomy produced a marked change in nest building activity. The animals were kept in individual compartments measuring 12 by 11 inches with a meshed wire screen covering the front. A device was attached to the outside of the cage which consisted of an axle with a roll of soft tissue paper one-half inch wide by 500 feet long and a cyclometer for measuring the length of paper taken from the roll. The end of the paper hung freely inside the cage within easy reach of the rat. The cyclometer was read at noon each day at which time the paper pulled in by the animal during the preceding 24-hour period was removed. Even though the paper was taken from the cage, normal rats, both male and female, built nests each day. Under constant conditions the amount of paper used from day to day remained "amazingly" constant for males and females alike.

It was found that hypophysectomy regularly produced a large and permanent increase in the nest building activity. Effects on nest building of gonadectomy, adrenalectomy, and thyroidectomy were also studied. Small increases were produced by adrenalectomy and gonadectomy, whereas large and permanent increase equal to that resulting from hypophysectomy was regularly produced by thyroidectomy. It was thought that the increased nest building activity after extirpation of the pituitary was due to the atrophy of the thyroid which it caused. Richter states that the hypophysectomized rats build larger nests in an effort to keep up their normal metabolism.

Referring to this study, Richter comments at a later date, "Thus, after thyroidectomy or anterior lobectomy and the resultant decrease in heat production has threatened the maintenance of a constant body temperature, the rats themselves made an effort to maintain a constant body temperature by building large nests around their bodies, thereby reducing heat loss" (2).

WATER BALANCE

One of the main regulators of water balance of the body is the antidiuretic hormone which is secreted by the posterior lobe of the pituitary gland. Extirpation of the posterior lobe results in the displaying by the animal of the symptoms of diabetes insipidus, i.e., abnormally severe thirst (polydipsia) and excessive urination (polyuria) (6). These difficulties are relieved promptly by injection of an extract from the posterior pituitary (7). Dehydration and death will follow, however, if the animals receive neither more than the normal amount of water nor hormonal injections. When dehydrating factors operate on the intact animal, an increased amount of the antidiuretic hormone is secreted which causes the kidney to excrete less urine, thus the body loses less water. On the other hand, when the body has an oversupply of water, hormonal secretion is decreased resulting in greater excretion of liquid (8).

Drawing from a previous experiment (9), Richter notes that if rats from which the posterior lobe has been surgically removed are allowed free access to an unlimited supply of water, they will ingest sufficiently large amounts to keep themselves alive and in good health. "The increased water intake," summarizes Richter, "represents to us an effort of the animal to maintain a constant internal environment, compensating for polyuria, which is primary" (2).

In a more recent report, Richter (8) indicates that experiments in his laboratories have shown that when rats from which the posterior lobes have been removed were not given access to water, they lost up to one-sixth of their body weight within eight hours after the operation and died much sooner than did intact animals that were deprived of water. When the operated rats were given access to water they consumed very large amounts, some drinking every day nearly double their body weight, and as a result kept themselves alive and in good health indefinitely.

SODIUM BALANCE

Adrenalectomized animals show an increase in the urinary excretion of sodium and a decrease of the sodium concentration of the blood (*10*). Young (*11*) has noted that rats usually die from excessive loss of salt in 10 to 15 days after adrenalectomy. It has been shown by Gaunt, Tobin, and Gaunt (*12*) that the length of survival of adrenalectomized animals is increased if they are forced to ingest a sufficient amount of salt. And Rali (*13*) has demonstrated that survival following adrenalectomy is enhanced by feeding sodium chloride.

In an experiment by Richter, (*14*) 13 adrenalectomized rats were put on a saltless diet following the operation. The survival rate was found to be zero per cent and the average length of life after adrenalectomy to be 11 days. With 26 animals continued on the standard McCollum diet (approximately 0.145 gram of salt per day) after adrenalectomy, the survival rate was 39 per cent and the average duration of life of the animals that died was 17 days. A third group of 13 rats was kept on the standard diet but in addition was given the choice of tap water or 1 per cent salt solution. These animals ingested a larger quantity of the salt solution after adrenalectomy, and the survival rate was increased to 69 per cent. Yet another group, made up of 5 rats, was kept on a saltless diet but was given a choice between tap water and a 3 per cent salt solution. Six times as much salt solution was ingested after adrenalectomy, and a survival rate of 80 per cent was shown. Richter concludes that the salt appetite is greatly increased by adrenalectomy and that the survival rate is greatly increased by virtue of the appetite.

In another study with adrenalectomized rats, using the single choice method, Richter and Eckert (*15*) found that the mortality, in general, varied inversely with the intake of sodium, with a reduction from 100 per cent to zero per cent. This study and also one by Young and Chaplin (*16*) have strongly supported the view that the adrenal gland regulates a specific hunger for sodium rather than sodium chloride. Bare (*17*) has also reported an increase in the strength of salt drinking behavior of adrenalectomized rats, as have Richter (*18, 19*), Clark and Clausen (*20*), and Mark (*21*). In the general conclusions of a rather recent article, Young and Chaplin state, "If adrenalectomized rats are given unlimited access to salt solutions at the optimal or near optimal concentration, they can survive indefinitely and in seemingly good health and activity" (*16*).

CALCIUM BALANCE

A hormone (parathormone) secreted by the parathyroid controls the concentration of ionic calcium in the blood. Removal of the parathyroid stops the flow of that hormone which in turn causes the calcium concentration of the blood to drop below normal. This affects the central nervous system, produces increased irritability of the peripheral nerves, and results in tetany which can be cured by an extract of parathyroid glands (*10*).

The conclusive state can also be checked by injection of calcium salts, and if administration of calcium is in sufficient quantities, all the symptoms of tetany can be held in check (*7*). However, if no treatment is given, the parathyroidectomized rat ordinarily loses weight, develops symptoms of tetany, and dies (*2, 11*). The parathyroid maintains the phosphorus as well as the calcium balance in the blood, but there is a rise in the level of phosphorus in the blood and, if administered in the diet of animals after removal of the parathyroids, results in or increases tetany as the case may be (*22*). It is also known that parathyroid tetany improves under treatment with strontium (*23*) and magnesium (*24*) salts.

In a study to determine the level of calcium appetite in rats before and after parathyroidectomy, Richter and Eckert (*25*) allowed the animals free access to a 2.4 per cent calcium lactate solution. The investigators report that the appetite for calcium lactate was definitely increased by removal of the parathyroid in 17 or 18 rats. The animals seemed to make an effort to satisfy their increased need for calcium by ingesting large quantities of the liquid. Although it seemed quite likely from the data that parathyroidectomized rats have a craving for calcium, it was felt that such a conclusion was unwarranted since only calcium lactate was employed. So the same investigators conducted another experiment in which rats were allowed to select from several different solutions (*22*). A markedly increased appetite for calcium solution, which included lactate, acetate, gluconate, and nitrate, and an aversion toward dibasic sodium phosphate were shown by the rats after parathyroidectomy. After the operation the rats also showed an increased appetite for strontium and magnesium salt solutions. When the operated animals were given free access to the calcium solutions, they made selections which reduced their mortality to zero, greatly improved the tetany, and either eliminated or reduced the loss of weight which had occurred. It was concluded that the decreased mortality and alleviation of deficiency symptoms of the parathyroidectomized rats given access to calcium solutions furnished additional evidence that rats have an ability to make selections conducive to their well-being.

Wilens and Waller (*26*) found that when completely parathyroidectomized rats on low calcium diets were given a choice of calcium lactate or sodium phosphate solution, they showed an increase in the amount of calcium and a decrease in the amount of phosphorus ingested. Young (*11*) comments that not only do parathyroidectomized rats select more calcium, but they also exhibit an aversion to phosphate. Such animals demand a diet high in calcium and low in phosphorus, and they refuse to partake of diets low in calcium and high in phosphorus.

CARBOHYDRATE BALANCE

That the lack of the pancreas causes diabetes was discovered in 1890, and it was later demonstrated that the pancreatic hormone is carried in the blood stream and that pancreatectomized animals can be kept normal by injection of the pancreas hormone, insulin (*7*). Insulin is important in carbohydrate metabolism and without it the concentration of blood sugar increases and polyuria and polydipsia develop (*8*).

A rat kept on a standard diet after pancreatectomy will develop all the symptoms of diabetes (*6*). (It is noted by Harrow (*10*) that pancreatectomy is fatal to the dog, with the death of the animal occurring in one to two weeks and that the length of survival of cats after removal of the pancreas is about five to six days.) Of 28 rats kept on the standard McCollum diet by Richter and E. C. H. Schmidt (*27*) in a study of behavioral and anatomical changes produced by pancreatectomy, only 10 of the animals survived the 40-day observation period following the operation. Pancreatectomized rats, this study found, became quite inactive. It was concluded that the inactivity was due largely to the inability of the animals to metabolize carbohydrate.

A later study by Richter and C. H. Schmidt, Jr. (*28*), was concerned with the questions of whether pancreatectomized rats seek fat or carbohydrate and of whether their food selections actually help to maintain the constancy of the internal environment. Seven early pancreatectomized rats were kept on the standard McCollum diet after operation, and all developed marked diabetic symptoms — polydipsia, increased food intake, decreased rate of growth, and hyperglycemia. Several weeks after these symptoms had developed the animals were placed on the self-selection diet. It was found that a marked appetite for fat and olive oil was shown by the rats and they ate little or no carbohydrate, which in this experiment was sucrose. An increased appetite was manifested by all 7 animals for yeast. On the self-selection diet the diabetic symptoms of all the rats either disappeared or were greatly reduced. Upon the return to the McCollum diet, diabetic symptoms were again shown by 4 of the 7 experimental animals.

In the same study another group consisting of 8 rats was kept on the self-selection diet for at least 40 days before pancreatectomy and for an equal period of time following the operation, at which time they were put on the McCollum diet. After pancreatectomy all the animals selected more fat and little or no carbohydrate. Measured in calories, the intake of carbohydrates changed from 36 to 9 per cent; fat from 38 to 68 per cent; and protein remained unchanged, 26 to 23 per cent. Diabetic symptoms appeared in none of the pancreatectomized rats as long as they were allowed to select their own diet. After being placed on the McCollum diet, 5 of the 8 animals showed polydipsia, increased food intake, reduced rate of gain of weight, and hyperglycemia.

From these experiments Richter and Schmidt conclude that the rats helped correct their diabetic symptoms by their selections of food and that their selections were in close agreement with the known needs of human diabetics. The authors conclude also that the various responses of the diabetic rats can be explained in terms of Claude Bernard's principle of the maintenance of the internal environment.

A later study by Richter, Schmidt, and Malone (29) dealt with the dietary selections of rats made diabetic by pancreatectomy. After removal of the pancreas, rats maintained on the standard diet developed diabetic symptoms. The animals were then placed on a self-selection diet, and they made dietary selections which caused all the diabetic symptoms to disappear. In general, the results confirm the finding of Richter and Schmidt (28), reviewed above, that the rats tend to make dietary selections which favor health.

SUMMARY

Much attention has been devoted in recent years to the self-regulatory functions of the body. The outstanding work of Cannon in this field is probably the most widely known. Whereas his studies have been primarily concerned with the physiological regulations of the internal environment, much of the work of Richter has dealt with the maintenance of the constancy of the internal environment through the operation of behavior regulators. Research pertaining to self-regulatory behavior in rats after extirpation of certain endocrine glands is reviewed.

Body temperature is regulated chiefly by the thyroid and the anterior lobe of the pituitary. Animals from which either of these glands has been removed will die within a few days if the external temperature is even slightly lowered. Nest building activity in normal rats is inversely related to environmental temperature. Thyroidectomized and hypophysectomized rats display greatly increased nest building behavior, producing larger and better constructed nests. This is interpreted as an attempt by the animals to compensate for reduced metabolism and to maintain a constant body temperature.

The water balance of the body is regulated primarily by a secretion of the posterior lobe of the pituitary. Surgical removal of this gland results in polyuria and other symptoms of diabetes insipidus which will be followed by dehydration and death. After such an operation rats who are allowed free access to sufficient quantities of water will ingest enough to keep themselves alive and in good health indefinitely. This may be viewed as an attempt by the rat to maintain a constant internal environment.

Adrenalectomy causes a decrease in the sodium concentration of the blood and in rats will result in death from excessive loss of sodium in 10 to 15 days. Adrenalectomized rats that are put on a self-selection diet including a sodium solution of optimal or near optimal concentration will ingest a sufficient amount of it to survive indefinitely in apparently good health. This is also viewed as an effort on the part of the animal to compensate for an internal deficiency and thus maintain a constant internal environment.

Calcium concentration of the blood is controlled by parathormone, a secretion of the parathyroid. Extirpation of this gland results in tetany and death. If parathyroidectomized rats are allowed free access to calcium solutions, they will consume a quantity sufficient to either eliminate or reduce the tetany and avoid death. This may likewise be seen as an attempt by the animal to restore the constancy of the internal environment.

Pancreatectomy stops the flow of insulin which results in diabetes. Such animals are unable to metabolize carbohydrates and should avoid them. Pancreatectomized rats develop diabetic symptoms while on the standard diet, but when placed on a self-selection diet, these animals ingest little or no carbohydrate and larger amounts of fat, thus either eliminating entirely or greatly reducing the diabetic symptoms. This is interpreted as an effort by the animal to maintain a constant internal environment.

It is concluded that rats have a tendency toward and the ability to induce, in a permissive situation, behavior which will maintain the constancy of the internal environment. It is felt that this principle of the constancy of the internal environment may be of value in understanding activities of the total organism.

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What Will Your Child Be Like?

STAFF OF *CHANGING TIMES*

The always interesting question of heredity has been dealt with in this selection with a light touch, but with sound facts. The mechanics of the hereditary process are described, Mendel's laws of distribution and dominance are explained, and the basis for sex determination is shown to be a matter of chromosome combinations. Some questions about coloration, facial features, and body build are answered in terms of hereditary principles. In the complex psychological processes such as intelligence and special talents, environment and heredity are both contributors. Notice the statement that "60% to 75% of the *variations* in intelligence are accounted for by heredity" — not that amount of an individual's intelligence, as is sometimes thought. Scientists are never seriously interested in the question of "how much is heredity?" for any feature or trait, but rather in the role of each of these two contributing factors — heredity and environment — for each of us inherits tendencies which develop under environmental influences.

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If your family is going to have a baby, chances are you are indulging in the favorite guessing game of soon-to-be parents:

What will "it" be like? Boy or girl? Blond or brunet? Presidential timber or plumber? Will it have the brown eyes of its mother or the red hair and blue eyes of its father? Will it "take after" Grandfather Jones — him of the terrible temper? Or Grandfather Brown, the inventor?

And if your child is already here, there are still a lot of questions. Where does that child get his moody disposition? Or his sense of humor? Or his inability to spell? Or, for that matter, his freckles and his snub nose?

Probably no one has ever had a baby without wondering fearfully beforehand whether the child will be whole in body and mind. And it is sure that no child ever born has entirely escaped family huddles over whom he favors.

This endless fascination with the mystery of inheritance is part of a parent's, and a grandparent's, prideful hope that he can pass on to his child some basic goodness. It is also part of the fear that somewhere there lurks a bad trait or attribute that will hamper the child for life.

There is just one thing that is absolutely certain about that child of yours. Unless he is one of a pair of identical twins, he will be unique. Never in history has such a person been produced, and never again will his kind be exactly duplicated. Whatever he is — good, bad or average — he is himself. He may have his father's nose and his mother's eyes, but when he is all put together, there is no one anywhere exactly like him.

The why of that truth goes back to Gregor Mendel and his experiments with garden peas and the whole theory of genetics that he proved with them. In case you are a little rusty on your biology, take a quick review before you get into sizing up your child's heredity.

CHROMOSOMES AND GENES

The male sperm and the female egg each give to their union 24 chromosomes — microscopically visible particles. They unite at the time of fertilization to give the new human being a total of 48 chromosomes, or 24 perfectly matched pairs. Every cell in the human being that subsequently develops has this same number of chromosomes.

Each chromosome contains many, many minute protein particles called genes, and each pair of genes carries with it the potentiality for the development of some specific characteristic. Genes are too small to be seen, but it is believed that as many as 20,000 pairs are inherited by each person.

One half of each pair comes from the father and the other half from the mother. Theoretically, one fourth of a child's genes come from each of his four grandparents and one eighth from each of his eight great-grandparents. The percentages don't hold up in practice, however. A child can receive many more genes through one grandparent or great-grandparent than another, and in many instances he receives none from ancestors five or ten generations back.

The genes themselves differ in character. They can be either dominant or recessive. The gene for brown eyes, for instance, is dominant in many families over its partner, which produces blue eyes.

A baby needs only one dominant gene to show its effects, but he must receive two identical recessive genes — one from the father and one from the mother — in order that a recessive trait be seen.

Geneticists often use a capital A to represent a dominant gene and a small *a* to represent a recessive one. Children, then, may get from their parents paired genes of one of three categories — AA when both parents pass on dominant genes for a particular characteristic, A*a* when one parent gives a dominant gene and the other a recessive one, and *aa* when both give recessive genes for that trait.

An A gene makes its presence visible in AA and A*a* people. An *a* gene will show up only in *aa* people.

This results in certain traits skipping generations. To understand the theory, take a husband

and wife who have each inherited a recessive gene for diabetes, but also a dominant gene opposing the disorder. Both will be normal because the dominant gene will subdue the recessive one. There is a chance, however, that both will hand down their "bad" recessive gene to one or more of their children, who will develop diabetes.

Suppose, then, one of the diabetic children grows up and marries a woman with two dominant genes for the normal production of insulin. Their children will all be spared the disorder because they will receive a good dominant gene from their mother along with the bad recessive one they get from their father.

Suppose, though, that the man with the history of diabetes marries a woman who, though normal herself, also carries the bad recessive gene. Then half of their children could develop the disorder.

The chances of two carriers coming together is, of course, enhanced when cousins marry, since they may have similar gene inheritance.

But recessive genes may fail to express themselves for many generations. Some genes are altered by a combination of other genes. Some have low penetration powers. A particular combination of inheritances and, possibly, of environment may be necessary to bring them out.

TRANSLATE INTO ONE HUMAN BEING

When you start putting all the theories to work in an effort to predict what your child will be like, you find, of course, that you can't draw a clear picture. You can, though, see how the genes could work to help make him the person he is to be.

Sex

There is as yet no answer to the question of which sex an unborn child will be, but it is known how sex is determined.

Of the 24 pairs of chromosomes in humans, all but one pair are matched in the two sexes. The one set that doesn't match is made up of the sex chromosomes.

The female has two X-chromosomes, so ova are always X-bearing. The male, however, has a large X-chromosome he received from his mother and a small Y-chromosome he got from his father. As a result, two types of sperm are formed — one carrying the X-chromosome and the other the Y-chromosome. If the egg is fertilized by the X-bearing sperm, the child will be a girl. If the sperm bears a Y-chromosome, the child will be a boy.

So it is the male's chromosome that determines sex, but there is no accurate way of telling which sex the baby is until it is born. It is not really true that boys or girls run in some families. A preponderance of either is simply a matter of chance.

Eyes

Generally, two blue-eyed parents produce blue-eyed children, and two brown-eyed parents produce more brown- than blue-eyed ones. But people with brown eyes can carry a hidden gene in favor of blue eyes and produce blue-eyed children. And many apparently blue-eyed people have flecks of brown in their irises and may produce children with a good deal of brown pigment in their eyes.

When the parents are mixed as to eye color, a sex factor seems to enter the picture. One researcher found that when the mother had blue eyes and the father brown, half the sons had blue eyes and half brown. But many more daughters had brown than blue eyes. On the other hand, when it was the mother who had brown eyes, there was a high percentage of blue-eyed sons and daughters.

Hair

If both parents are blond, the children will probably also be blond, but brunet parents can have either blond or brunet children. Red hair seems to be determined by a separate and highly complicated gene. In many cases it appears to be recessive to the brown tones.

Two straight-haired people have straight-haired children, and two people with wavy hair have wavy-haired children. If one partner has straight hair and the other curly or wavy, the kids come out about half and half.

Facial Characteristics

If one parent has a narrow nose and the other a broad one, the child's nose will be narrow. Also, noses that are distinctively shaped — pug, hooked, extra long — are usually passed on by the one partner with that characteristic.

The same is true of other dominant facial features — dimples, a cleft chin, protruding lips, high cheek bones, freckles. However, a child isn't likely to have a receding or narrow chin unless both parents have one.

Body Build

Tall people are likely to breed tall children, short people, short ones (if prior ancestry is consistent), and medium people, some of all three. The child of one short and one tall parent is likely to be on the short side.

The body type of a child — rounded, athletic or slender — may or may not be an inherited tendency. Environment may play at least as large a role. Athletic ability probably is not inherited.

Left-handedness, incidentally, follows a rather erratic pattern, but left-handed people tend to raise left-handed children.

Intelligence and Talents

From 60% to 75% of the variations in general intelligence are accounted for by heredity — good or bad. But genes probably play a much lesser role in the presence or absence of special talents and abilities.

A good intelligence heredity on one side of the family may override a poor one on the other, and it is known, too, that good environment can raise a child's IQ by as much as 20 points, and a poor environment can lower it.

Great artists, writers and business tycoons are probably not born, but some special abilities seem to be inherited. Outstanding among these are the aptitudes needed for music, mathematics and invention. Word fluency and spelling ability also seem to get an assist from inheritance.

But the total achievement of a person depends on both heredity and environment.

Personality

Children don't inherit their total personalities, but they depend a great deal on inheritance for their basic adjustment to society and to stress. One authority lists these as inherited personal traits: general emotional stability or lack of it, personal tempo for living, persistence in direction and ease of association with others. Another adds violent tempers to the list.

Diseases and Abnormalities

Inheritance is involved in physical disorders in three ways: A child can inherit the ailment itself, as in color blindness, diabetes and hemophilia; he can inherit a congenital weakness of a specific organ, as in some vision and hearing defects; or he can inherit a susceptibility to a disease, such as rheumatic fever, asthma and certain forms of cancer. Also, a child can inherit a tendency to suffer crippling effects from poliomyelitis.

The list of disorders with a possible genetic source is so long that it has been estimated that between 3,000,000 and 5,000,000 Americans have hereditary diseases and defects. Happily, though, a child can inherit tendencies for immunity to certain diseases as well as predispositions toward them.

Malformations, too, may be inherited, although many are accidents during pregnancy or at birth. Cleft palates, harelips and clubfeet are common, and correctable, inherited abnormalities.

Some weaknesses, susceptibilities, immunities and malformations are carried by dominant genes and will always appear if both father and mother are effected or 50% of the time if only one is affected. But others are recessive and may not appear at all for several generations.

Longevity

A child born to long-lived parents is almost sure, barring accident, to live longer than the average person. Longevity can be inherited from either parent.

SOMETHING TO GROW ON

Probably, thinking about it, you have decided that your child will have a pretty good heritage. Maybe there are a few family weak spots. Don't worry about it. Practically never do all the bad genes — or all the good ones — wind up in the same person.

And remember, heredity is the beginning, not the end, of destiny.

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How Much Can We See?

BRIAN O'BRIEN

In many ways the human eye is the most remarkable biological structure nature has yet developed. Although it has been the subject of intensive study for many years, there are still some aspects of its operation we do not fully understand. It is an optical instrument (which we understand quite well), a chemical "laboratory" (which still holds some mysteries), and an electrical encoding-transmitting instrument (which we are beginning to understand). It is also a responding organ over which we have a high degree of precise control. Since so much of our knowledge of the world around us comes through visual stimuli, we should know how the eye operates, what its limitations are, and what it contributes to the way we see the world.

Dr. O'Brien was director of the Institute of Optics at the University of Rochester when he prepared this paper. He is now vice-president in charge of research of the American Optical Company. The selection has not appeared in print heretofore, but was read by Dr. O'Brien during the intermission of the Sunday afternoon Philharmonic Orchestra radio broadcast some years ago. The program sponsor, The U.S. Rubber Company, and the author have granted permission for its use here.

We carry in our head what are really twin television cameras, our two eyes. I liken them to television cameras rather than to ordinary photographic cameras because the functioning of the human eye is a sort of television.

Each eye has a lens, just as an ordinary camera has, and at the back of the eye is a light-sensitive screen upon which the lens forms images of everything upon which we look. The light-sensitive screen responds chemically, and to this extent resembles the photographic plate. But in addition each element of the screen is connected by transmission lines to the rearmost part of the brain. There are more than a million of these communication channels in just one small head, an array that would put to shame the largest and most elaborate telephone exchange. The signals which travel along these lines, the fibers of the optic nerve, are electrical, although, more accurately, they must be described as electro-chemical. These remarkable living cameras and their transmission lines are finer in many ways than any camera which man has yet made, but they have their limitations too. These limitations and the reasons for them are matters of interest to all of us.

Try to see a distant bird or airplane against an expanse of sky. Suddenly you find it, and after that following it is easy. But now try to point out the object to someone else. He, too, must search a moment before he finds it. Why is this? You can see a wide expanse of sky all at once. Why did you not see instantly the small spot, the airplane or the bird?

Obviously there is something about our eyes which requires that they be pointed in order to see fine detail. Have you a book or newspaper at hand? Look at an ordinary printed page and find a semicolon. The dot and comma which form it are easy to distinguish. But now look fixedly at some letter three printed lines directly above, and as you do so you lose the dot and comma — they become indistinguishable blurs. Our eyes give us a broad picture, but the picture is really sharp only in the center.

Some lack of sharpness at the edges of the picture is a property common in cameras. It is a defect of most lens systems. In the case of our eyes, however, there is a more important reason for this lack of sharpness. It is to be found in the structure of the light-sensitive screen.

This screen, the retina, is made up of a large number of tiny nerve endings, each sensitive to light, and all of them packed very closely together. Some of these nerve endings are rod shaped, some are cone shaped, and they are distributed over the screen in a certain pattern. The outer edges of the screen are mostly rods. Toward the center the cones become more numerous, and in the very center of the screen is a small area called the fovea containing only cones. From these rods and cones nerve fibers lead to the area of the brain where visual sensation is affected. This is the television system. However, the hook-up is not uniform. Some of the nerve fibers are private lines, some are party lines — and it appears that the private lines serve the cones, while the rods must share party lines. Since the edges of the retina have only rods it is no wonder that there is a certain jumbling of signals from those areas. And it seems clear, too, why only in the small rod-free center of the screen, the fovea tightly packed with cones, do we secure the high resolving power, the ability to discriminate fine detail. The image there, at the center, goes to the brain over private lines.

This structure, giving sharp vision only in the fovea, may seem like a serious limitation. Actually it is not. Each eye is a ball, mounted in a cushioned orbit, and free to turn.

Its movement is controlled by six small muscles and the control of these muscles is so perfect that we follow the objects of interest to us and are scarcely aware of the thousands of rapid eye movements which we make every waking hour. Watch the eyes of someone who is watching a tennis match if you want to see gymnastics quite the equal of anything which is happening on the court.

How much and how little light can we see? The page of a book in direct sunlight is ten thousand times as bright as the same page held one foot away from an ordinary candle, yet we can read by either light. Full moonlight is only one-fiftieth of a foot candle — that is, one-fiftieth of the illumination one foot from a candle. We can still see, but it is impossible to read fine print by moonlight; here we have passed the lower limit for keen vision.

Looking at a landscape in moonlight we still see a great deal, but fine details are lost and color is gone. Trees and grass do not look green but a sort of gray. A blue dress has become gray. With care we can drive a car under moonlight, but not with the vision we have in daytime. Pointing our eyes at something no longer sharpens the image. In fact, if we try to see an object over there in the shadows, we find it is actually clearer when we look a little above or below or to one side of it.

When the moon has set, these changes are much more pronounced. We can still see objects on the ground under the starlit sky if they are big enough and close enough, but our vision in the fovea, the central part of the retina, has gone. We are blind now in the very region where we had our keenest daylight vision. Why is this? Why is it that under the starlit sky with the illumination only one hundred-millionth that of direct sunlight we can still see but in such a different way?

The key to this riddle lies in the rod and cone cells which I mentioned before. The rods cannot give us such sharp details of vision, but they are far more sensitive than the cone cells. When we step from a bright room out into the darkness at night, we find that we are quite blind temporarily. This is because the rods cannot act at once, they must have time to regain the sensitivity which they lost during exposure to the light. Usually they require twenty minutes or more to regain this to the fullest extent. It is these rods which give us our night vision, and it is because there are no rods in the fovea that the very central part of our visual field is blind at night.

Now look around the room in which you are sitting. All the details of the objects which you see are visible because they are brighter or darker than their background, or because they have a different color.

Color! What do we mean by color? You know that light consists of waves like radio waves but very much shorter. The longest wave lengths we can see are red, the shortest violet, with the other colors lying in between. White light is a mixture of many wave lengths, and most of the colors of nature consist of several wave lengths in different proportions. Our eyes respond differently to these different wave lengths, and send different signals to the brain, and this results in the sensation of color.

Now, it was this sensation of color — you remember? — which grew dull as the light grew dim, became weak in moonlight, and was lost entirely under the moonless sky. Since only the rod cells are sufficiently sensitive to work in dim light it must follow that the rods are blind to color. And such, indeed, is true. To see color we must have enough light so that the cone cells can function. And somewhere in the structure and the mechanism of these cone cells lies the secret of color vision. In the fovea, where there are only cones, our color vision is excellent. So it is clear that only cones are necessary to provide our entire range of color sensations.

I wish that I might tell you, in closing, why we see color, how the cones respond to different wave lengths and send their color signals to the brain. Unfortunately I do not know. It is one of the mysteries of vision. But while we do not know the mechanism of color vision, the main facts are clear. We know how much and what kind of color we can see. We can specify color by suitable numbers so that a colorist can duplicate it. And we can tell what the quality of a color photograph or color television must be in order to satisfy the eye. The requirements give us a new respect for these eyes of ours and set a high mark for the motion picture and television engineer to shoot at.

But it is never very satisfactory to set numbers and limits when the fundamental reasons are unknown. It is the scientists' job to learn the reasons. Someday, and I hope soon, we shall have a better understanding of these remaining mysteries about the wonderful mechanism by which we see.

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Our Taste Receptors

LLOYD M. BEIDLER

Taste is one of the original five senses discussed by Aristotle (but we have learned about several more since then!). It is one of the oldest senses in the evolution of man, and is better developed in some other animals than in man. It is also sharper in children than in adults. Although we know a great deal about taste, we still lack *complete* knowledge of it, as this authority points out. He draws upon the work of psychologists and of biologists to explain the present state of our understanding. Although Beidler's major interest is in relating the nature of the chemical stimulus to the experiences of taste, he recognizes the importance of sense organ structure, taste qualities, taste blindness, and other matters of psychological interest to this discussion. Here is a good example of attempts to construct theory upon known facts, and how, in even as simple a matter as taste, nature's secrets are difficult to extract.

Dr. Beidler is professor of physiology at Florida State University and has training in physics as well as biology. His article appeared in *Scientific Monthly* for December, 1952 (pp. 343–349). It is reprinted by permission of the publisher and the author.

NOTE: Three figures have been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the author's permission.

Man is said to possess five primary senses; vision, hearing, touch, smell, and taste. The two latter senses are thought to be the oldest in the evolution of man. It is by means of smell and taste that an animal perceives a change in his chemical environment. This is of utmost importance for lower animals, since a great deal of their behavior is related to the search for suitable food. Fish, for example, have chemoreceptors over much of the exterior surface of the body, which facilitates the detection of food in the surrounding water. In higher animals the specialized chemoreceptors are confined to particular regions, conveniently located so as to sample the intake of food. In man the gustatory receptors are confined to the oral cavity — in particular, the dorsal surface of the tongue — and the olfactory receptors are located in the upper nasal region. Thus it is possible to sample both the food ingested and its aroma. Because of the location of the chemoreceptors, it is often thought that both taste and smell are vitally related to man's nutrition. Many recent studies have indicated that this relationship is very real.

Although the importance of both gustation and olfaction has been recognized for many years, little is yet known as to how the chemoreceptors respond to a change in their chemical environment. There are two reasons for the lack of knowledge concerning the chemical senses as compared to those of vision or audition. First, the exact nature of the stimulus is not known, although it appears to be physicochemical. On the other hand, in vision the stimulus is the photon and in audition it is the change in air pressure. Second, it has been found to be more difficult to study the responses of the chemoreceptors with the usual physiological techniques that have been applied and found to be so rewarding in the study of the visual and auditory receptors. This is particularly true of the olfactory receptors.

The study of the sense of taste may be approached from one of two directions, the choice being dependent upon the questions one wishes answered. First, one may be concerned with the behavioral responses that are initiated when the chemoreceptors are chemically excited. In the past, such psychological factors constituted the major portion of all studies of taste. The studies were not limited to man alone — both lower vertebrate and invertebrate forms were investigated. These studies provided answers to many questions concerning the over-all behavioral response of an individual to various taste substances — answers which are of utmost importance to the economic welfare of man, for they deal with such topics as nutrition and the palatability of food.

The second approach concerns itself with a molecular explanation of the chemical excitation of the nervous system and the specific sensitivity of the chemoreceptors. This involves one of the most important biological problems of our time: the relationship of the structure of molecules to their physiological action. The taste end organs are ideally suited for such a study since they can respond to thousands of different substances under normal physiological conditions. In addition, the end organs relay their information to other parts of the nervous system in the form of electrical impulses and thus present opportunity for the experimenter to study the reactions of this system with quantitative methods not usually possible in other areas of biology. It is this approach that is to be discussed here.

MORPHOLOGY OF THE TASTE RECEPTORS

The receptors associated with taste are usually found in the taste buds. These end organs are composed of two types of cells, one a supporting cell and the other believed to be the taste cell. Both types of cells are grouped together into a small budlike structure, the taste bud. A narrow passage, the taste pore, connects the taste bud to the open surface of the tongue. Thin hairlike filaments project into the taste pore from the taste cells, and many believe that it is the filaments that are stimulated by the substances that are tasted. The taste bud is innervated by small nerves that arise from a subepithelial plexus, wind around the taste cells, and terminate in knoblike projections on the cell.

The taste buds are found primarily on the dorsal surface of the tongue, although they may be sparsely distributed over other structures of the oral cavity. On the tongue they are located in the trenches of the circumvallate papillae, the grooves of the foliate papillae, and above the dermal core of numerous fungiform papillae. The anterior two thirds of the tongue contains only fungiform papillae and is innervated by a portion of the lingual nerve. These taste fibers branch away from the lingual nerve to comprise the chorda tympani nerve, which then passes through the middle ear and joins the facial nerve. The posterior third of the tongue is innervated by the glossopharyngeal nerve. The vagus nerve may receive taste fibers from other portions of the oral cavity.

The end organs of taste are unusual in their close association with their nerve supply. Thus if one cuts the nerve, both the nerve and the taste buds it innervates degenerate. During the eventual regeneration of the nerve fibers, new taste buds are formed from the epithelial tissue of the tongue, so that ordinary epithelial tissue is transformed into specialized taste cells that are able to respond to dilute solutions of various kinds. How this transformation is accomplished is not known.

Although it has been shown that the taste end organs are functionally of different types, no anatomical differences among the taste buds of the tongue have been observed. Recently, however, the enzymes that are present in the taste buds and surrounding tissue have been studied. Histochemical preparations have revealed that esterase, hexose diphosphatase, yeast adenylase, acid phosphatase, lipase, muscle adenylase, and ribonuclease are all localized in gustatory regions of the tongue. These enzymes are located not only in the taste buds, but some are also localized in neighboring tissue. Selected substances that have well-defined tastes have been shown to affect one or more of the six enzyme activities. It is proposed by the investigators that the mechanism of taste stimulation involves the reaction of the taste substance with enzymes. If this be true, then the result of such histochemical studies on gustatory regions would be of fundamental importance to our understanding of the nature of the taste receptor.

Our present knowledge of the morphology of the cellular structures of taste contributes little to our understanding as to how a biological system can detect and differentiate a large number of chemical substances. It is possible to stimulate a single papilla of the human tongue and study the response, but each such papilla has a large number of taste buds, so that single taste bud stimulation has not been achieved. Fortunately, however, the rat usually has but one taste bud per fungiform papilla, and the papillae themselves are far enough apart so that single taste bud stimulation is possible. An experiment utilizing such stimulation must, however, rely upon the electrical recording of the response of the taste nerves innervating the taste bud, rather than classical psychological methods. Such an experiment would indicate the responses of a single taste bud, but is this organ the ultimate unit of taste, or is it the individual cell within the taste bud? This is but one of the fundamental questions that confront those interested in chemoreceptors.

TASTE MODALITIES

It is commonly believed that there are four fundamental taste qualities, the salty, sour, bitter, and sweet, from which all other tastes can be derived. This is perhaps the most important of all the concepts upon which our present theories of taste are constructed. What evidence supports the concept of four taste modalities?

It was recognized very early that not all areas of the tongue responded to a given substance in the same manner. For example, sweet tastes are perceived near the tip of the tongue, and bitter tastes near the back of the tongue. Scientific inquiry confirms the fact that the sweet sensitivity is greatest at the tip, the bitter at the back, the salt at the tip and sides, and the sour on the sides. This would suggest that each of these regions possesses receptors that respond predominantly to compounds which elicit one of the four primary qualities.

Because the fungiform papillae of the human tongue are rather large, a single papilla can be stimulated with the aid of a fine brush containing any particular solution desired. In this manner the specificity of the taste buds associated with a papilla can be tested, using solutions of sucrose, quinine, sodium chloride, and hydrochloric acid. These four substances are often used as representative of those that elicit the pure sweet, bitter, salt, and sour tastes, respectively. Some papillae react only to sodium chloride, others only to hydrochloric acid, and others only to sucrose. The majority of papillae, however, respond to two or more of the four test solutions. Since a single human fungiform papilla has several taste buds associated with it, it has been suggested that the individual taste bud may respond specifically to one of the four types of stimuli, and that the number of stimuli that excite the taste buds of a single fungiform papilla is a result of the chance combination of the four types of taste buds.

If there are but four primary taste qualities, and if there are at least four substances that are able to elicit the pure taste representative of each quality, then it should be possible to duplicate the taste of any given substance by a suitable mixture of these four substances. Von Skramlik has succeeded in duplicating the mixed tastes of many inorganic salts in this manner and mathematically coding the mixed taste by quantities of each of the four substances comprising the mixtures.

The differential sensitivity of the four taste qualities to various drugs also supports the four modality theory. The juice of gymnema leaves applied to the surface of the tongue decreases the sweet and bitter sensitivities, whereas the salt and sour sensitivities remain unchanged. Cocaine applied to the tongue decreases all sensations normally arising from it. Pain, however, disappears first, and then bitter, sweet, saline, and sour sensations are eliminated, in that order;

touch is the last to disappear. Whether such specificity is a direct result of the action of the drug on the taste cell itself or on the nerve fibers innervating it has not been ascertained. Electrophysiological studies show, however, that the bitter nerve fibers are much smaller in diameter than salt and sour fibers, and it has been established that such drugs interfere with nerve conduction in a manner that is dependent upon the nerve diameter.

The most striking evidence in support of the four modality theory has been presented by Pfaffmann. Taste nerve strands containing a single active nerve fiber were dissected from the taste nerves innervating the tongue of the cat. The electrical activity was then recorded from the single fiber as various solutions were dropped on the surface of the tongue. Not all the nerve fibers tested responded in the same manner to a given number of solutions. Three different fiber groups were classified by Pfaffmann according to the solutions to which they responded. The first group consisted of the acid fibers, which responded to potassium chloride, acetic acid, and hydrochloric acid. The second group, the acid-salt fibers, responded to potassium chloride, sodium acetate, calcium chloride, hydrochloric acid, acetic acid, and sodium chloride. The third group, the acid-quinine fibers, responded to acetic acid, hydrochloric acid, and quinine. Of the salts, only sodium chloride, which gave no response, was tested on the third group. Saturated sucrose did not stimulate the fibers tested by Pfaffmann, although it has recently been demonstrated, using different electrophysiological techniques, that taste nerve activity in the cat can be recorded in response to sucrose, the threshold being under 0.25 *M*. It is concluded that the sour taste is mediated when all three fiber groups are stimulated simultaneously. Stimulation of the acid-salt fiber group alone would mediate a salt response, whereas the acid-quinine group would mediate a bitter response. The single nerve fiber experiments indicate that the four taste modalities are reflected peripherally to the presence of receptors that are somewhat specific to compounds associated with the modalities, but not exclusively sensitive to compounds associated with any one modality.

Additional modalities are often postulated, especially those relating to the alkaline and metallic tastes, to serve as a basis for tastes not satisfactorily included in the classical four modality theory. It is also true that the good agreement between the experimental facts and the four modality theory may be a result of the limited number of chemicals used in the study, since four compounds are usually chosen, each of which is indicative of one of the four modalities. This theory is a result of but one of the first steps in our attempt to understand how the tongue can respond to thousands of different compounds producing different sensations. It is a useful theory, but an oversimplification of the complexities associated with taste phenomena.

SALTY TASTE

Sodium chloride, or common table salt, elicits a sensation designated as salty. Other salts applied to the human tongue produce tastes that are mixed. For example, potassium chloride has a definite bitter as well as salty taste. Not only does the taste depend upon the particular salt chosen, but it is also dependent upon the concentration of the salt. For this reason it is useful to study electrophysiologically the reaction of the chemoreceptors that respond to the salts and not to the bitter or sweet substances.

Records of the electrical nervous activity of the chorda tympani nerve of the rat have shown that it is the cation that has the predominant effect on the ability of the salt to stimulate the salt receptors. The anion has a lesser effect but is nonetheless important. No physical or chemical property of the salts has yet been found to be solely responsible for the ability of the salt to stimulate. However, it does appear that nonelectrolytes cannot stimulate the salt receptors.

SOUR TASTE

Almost all the substances that elicit a sour sensation contain an acid. For example, there is acetic acid in vinegar, citric acid in lemons, lactic acid in sour milk, and malic acid in apples. For this reason the sour taste has always been associated with acids and, therefore, with the hydrogen ion. Since the hydrogen ion is the only one all the acids have in common, one might assume that it is this hydrogen ion that is responsible for the stimulation of the acid receptors. However, human threshold concentrations for various acid solutions are not at equal pH. In fact, acetic acid evokes a much stronger sensation of sourness than does hydrochloric acid at the same pH. On the other hand, hydrochloric acid is a more powerful stimulus than is acetic acid at the same molar concentration. The lack of a simple correlation between the pH of a solution and the sour sensation for which it is responsible has disturbed those interested in taste for many years.

From these observations two different interpretations have evolved. First, it is known that saliva acts as a buffer and therefore reacts with any acid solution applied to the tongue, so that the available hydrogen ions decrease. If, however, a weak organic acid such as acetic acid is placed on the tongue, the buffering effect of the saliva is not as great, since the acetic acid tends to dissociate to produce more hydrogen ions if those already present react with the buffer. Thus the buffer effect of the saliva present on the tongue allows the solutions containing weakly dissociated organic acids to be more effective in stimulating the acid receptors than solutions of the same pH containing strong acids. Liljestrand found that buffer mixtures of acetic acid and sodium acetate could be prepared so that a sour threshold would be found at pH 5.6, whereas the threshold for acetic acid alone was pH 3.9. He concluded that the sour taste is due to the titratable acidity of the solution. It should be remembered, however, that Pfaffmann found a large number of single taste fibers that responded to both acid and salt stimulation of the tongue of the cat. It is therefore possible that the salt of the buffer mixture itself contributes to the threshold measured by Liljestrand.

The second interpretation assumes that the acids must enter the receptor cell and, therefore, pass through a lipid phase. Taylor has studied the taste thresholds of various acids and concludes that those weak acids that are more lipid-soluble are also the acids which elicit a sour sensation at a hydrogen ion concentration lower than the strong acids that are not appreciably lipid-soluble. One difficulty with this explanation is that acids usually enter cells rather slowly, whereas the sour receptors of the rat can respond to an acid solution well within 50 msec after the solution is applied to the tongue.

It can readily be seen that those interested in studies of taste are confronted with the same problem that disturbs biologists in other fields; i.e., there usually exists no simple correlation between the physical or chemical properties of a group of substances and the extent of the biological effects they produce on living cells.

SWEET TASTE

The sweet taste is produced by a variety of un-ionized organic compounds, particularly by certain polyhydric alcohols. A few electrolytes such as the beryllium salts and the amino acids may also taste sweet. The sugars are the most common molecules that are sweet to man. Since they usually are important as sources of food, many investigators regard the sweet taste as being closely associated with the nutrition of the animal. Several artificial sweeteners, however, have been found to elicit a sweet taste much more intense than any of the sugars of equal concentration. One substance, saccharin, is used generally as an artificial sweetener, but has no known nutritional value.

BITTER TASTE

Whereas the sweet sensations are usually associated with nutritionally important foods, it is the bitter sensation that is associated with substances harmful to man. This statement is, of course, an overgeneralization of the known facts; nevertheless, a large number of alkaloids and glucosides are both distastefully bitter and poisonous. Among this group of substances are those said to stimulate man's sense of taste at unusually low concentrations. Quinine hydrochloride has been reported to elicit a bitter sensation at a concentration of 4×10^{-5} *M*. This threshold is one of the lowest of all those reported for taste but yet is not as low as some olfactory thresholds. For this reason the statement is often made that the olfactory receptors are much more sensitive to chemical stimuli than are the gustatory receptors.

PHYSIOLOGICAL CHARACTERISTICS OF THE TASTE RECEPTORS

The measurement of threshold for a large variety of compounds is the most widespread method used in the study of taste. Threshold is usually determined as the least concentration of a substance necessary to elicit a reaction from an animal as measured by a well-defined behavioral response. Since most substances elicit a mixed sensation of taste, it is difficult to ascertain that the threshold measured by means of a behavioral response is also the threshold of a particular type of taste receptor. This is readily comprehended when one compares the taste of NaCl and KCl at different concentrations as reported by Skramlik (Table 1).

Table I

Molar Concentration	Taste of NaCl	Taste of KCl
0.009	No taste	Sweet
.010	Slight sweet	Sweeter
.015	Sweeter	Still sweeter
.020	Sweet	Sweet, bitter
.030	Strong sweet	Bitter
.040	Salty sweet	Bitter
.050	Salty	Bitter, salty
.070	Saltier	" "
.100	Still saltier	" "
.200	Pure salty	Bitter, salty, sour
0.500	" "	" " "

Thus, if one defines threshold as that concentration of a substance which can be detected as different from water, then KCl would have a lower threshold than NaCl. If, however, one defines threshold as the lowest concentration of a substance which can be identified to possess a salty taste, then NaCl would have a lower threshold than KCl. It is even more difficult to compare the thresholds measured by behavioral responses of animals other than man to the thresholds of a particular kind of taste receptor.

The threshold value is but one point on the total curve relating response to concentration. The complete curve can be determined by measuring the magnitude of the electrical activity of the chorda tympani in response to the activation of a given group of receptors on the tongue by various concentrations of a substance (Fig. 1).

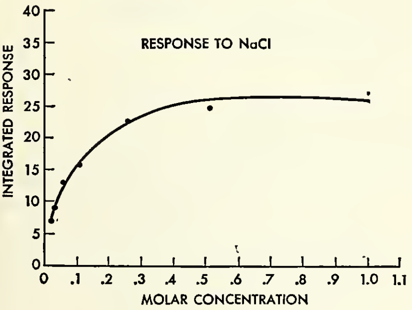


Fig. 1. Curve showing the electrical activity of the taste nerve (integrated response) as various concentrations of sodium chloride solutions are flowed over the tongue of the rat.

Note that a point is reached where a further increase in concentration would not result in an appreciable increase in response. This maximum value is called the saturation level. The measurement of response-concentration curves of a large number of salts reveals that each salt possesses a unique saturation level. Such data are important in the formulation of a theory of taste receptor stimulation, since the saturation levels indicate a dependence upon the physicochemical properties of the structure of the chemoreceptors that are directly involved in stimulation and not merely a dependence on the total number of molecules available to the receptor.

The taste receptors of the tongue respond very rapidly. Several investigators have measured the interval between the application of a salt or acid stimulus and the resulting activity as recorded from the taste nerve of the rat and found a latency of the order of 50 msec.

The receptors show an initial adaptation during the first two seconds of response. They do not adapt completely, however, but reach a steady level of response that may be maintained for many minutes during continued salt stimulation. When the chemical is washed from the tongue with water, the response declines rapidly at a rate characteristic for each substance.

SPECIES DIFFERENCES IN TASTE

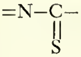
Taste experiments have been performed on many types of animals, both vertebrates and invertebrates. The question then arises, are there differences in taste among various animals, and if so, to what extent? This question is difficult to answer because the behavioral criteria of response are dependent upon the type of animal chosen. A partial answer is given by electrophysiological studies of the taste nerve activity of several mammals.

The electrical activity of the chorda tympani nerve was measured as various solutions were applied to the tongue. Large variations in the response to a number of substances were found among the rat, guinea pig, cat, dog, hamster, and rabbit. For example, the hamster responded very well to low concentrations of various sugars, whereas the cat or dog responded rather poorly. The response to quinine was always rather poor, with the exception of the cat. The most noticeable variation was found in the ability of the various animals to respond to a given series of inorganic chloride salts. For example, the rat, guinea pig, and hamster all responded to a greater extent to NaCl than to KCl at the same molar concentration. The exact reverse was found to be true with the cat, dog, and rabbit. The above observations lead one to conclude that there are indeed variations in ability of the animals to respond to certain chemical substances.

GENETIC DIFFERENCES IN TASTE

It has been demonstrated that phenylthiourea (PTC) tastes bitter to some people and is tasteless to others. About 30 per cent of Americans do not perceive the bitter taste of dilute solutions of PTC. Furthermore, the lack of sensitivity to PTC in this group of people (nontasters) is inherited according to simple Mendelian laws. This differential taste sensitivity is not common to all bitter substances; it is not found with quinine, urea, strychnine, etc. There are, however, substances closely related to PTC which behave in a similar manner. It is assumed that the differences presented by these substances are determined by the same genetic factors that control the taste differences with PTC.

Equally important is the fact that the reactions which occur with these substances are chemically specific. The chemical group common to all these substances is:

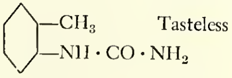


$$=N-\underset{\underset{S}{\|}}{C}-$$

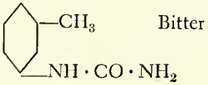
The presence of this group in the structure of a molecule is itself a necessary criterion in determining whether it produces a differential taste sensitivity similar to PTC. It recently has been shown that it is also common to a large number of antithyroid substances.

Chemical specificity is a common occurrence in biological phenomena, and it is therefore not surprising to find that taste is quite dependent upon the chemical structure of the stimulating substances, including the orientation of the substituent groups of the molecule. For example:

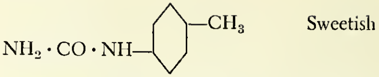
o-Tolylurea



m-Tolylurea

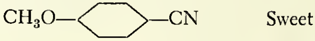


p-Tolylurea

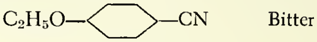


A slight change in one part of a molecule may also change the taste:

p-Anisonitrile



p-Ethoxybenzonitrile



Stereoisomers may also have different tastes. Dextrorotatory asparagine is reported to be sweet, whereas levorotatory asparagine is tasteless. These observations suggest that both sweet and bitter substances may react with specific molecules located in the taste end organ and that the reaction is dependent upon the configuration and orientation of all the molecules involved.

THEORIES OF TASTE STIMULATION

Theories as to the mechanism involved in the stimulation of the taste receptors have been proposed by many speculators. Since scant factual information concerning the chemoreceptors themselves is available, the theories offer little that is concrete. Any theory, to be valid, must account for several well-defined facts:

1. The taste receptors respond rapidly to a chemical stimulus.
2. All substances to be tasted must be in a liquid state.
3. A large variety of substances will stimulate the taste receptors.
4. The concentrations of the chemical stimulants for threshold excitation are seldom very large.
5. Many of the substances applied to the surface of the tongue are usually classified as nonphysiological. For example, 1.0 *M* NaCN, 10 mM strychnine and acids of pH 2.5, all have been demonstrated to stimulate taste receptors without resulting in rapid deterioration of the receptor cells themselves.
6. The taste receptor rapidly elicits a steady level of response, the magnitude of which is a function of the concentration of the applied substance.

7. The response to many substances remains constant over a long period of stimulation.
8. Receptor stimulation must be followed by the electrical depolarization of the nerve membrane and possibly preceded by the depolarization of the end organ itself.
9. The taste response declines rapidly with a water rinse.
10. Chemical specificity is a property of the receptors.
11. There are genetic variations in the taste ability of humans.

Two prevalent theories of taste stimulation that are able to account for many but not all of the properties of the receptors are worthy of note. The first theory maintains that the taste substances participate in an adsorption process, possibly with proteins, at the surface of the receptor. As a direct result of this, there is a rapid depolarization of the receptor surface which spreads to the attached nerve fiber and excites it. The second theory postulates that the taste substances enter the receptor cell and interact with enzymatic processes. These chemical events are in turn related to the eventual depolarization of the associated nerve fiber. Both these theories are broad enough so that definite proof or disproof is difficult. They are similar in that they both rely upon adsorption to account for the properties of chemical specificity, and both rely upon changes in cellular protein structure to explain genetic phenomena. They differ in that the enzymatic theory supposes that the taste substances enter the receptor cell and that the same substances, or possible end products of a chemical reaction, must also leave the cell. This must all be performed very rapidly and with a large variety of substances, some of which are very toxic even in low concentrations.

Many variations of these two general theories have been proposed. In fact, there is no reason to assume that there is but one type of stimulating mechanism for all types of taste substances. This is especially noteworthy when one considers that the sour and salty tastes are always elicited by electrolytes and never by nonelectrolytes, whereas the substances eliciting the bitter or sweet taste may be either electrolytes or nonelectrolytes. At present, most theories basically assume that there are four types of receptors corresponding to the four modalities. An understanding of the mechanism of receptor stimulation is but one step toward a complete understanding of taste phenomena. How the nerve messages, which are evoked by the chemical stimuli applied to the tongue, are translated into a sensation of taste is little understood.

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SUGGESTIONS FOR FURTHER READING

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PART VIII *The Behaving Organism Is Social*

MAN IS JUST AS TRULY A SOCIAL CREATURE AS HE IS A BIOLOGICAL CREATURE. Few individuals live a solitary existence. When conditions do force isolation from society, special problems of adjustment arise and the person may lose some of his human characteristics. Thus, in considering human behavior, one must take into account interpersonal as well as individual and biological factors.

Social psychology is a new field — far newer, for example, than social thought. Hence it has "inherited" much doctrine from various prescientific sources. Only quite recently has the experimental method been employed successfully in social research. Writers on the subject typically avoid a systematic or general theoretical approach because they feel it is too early to crystallize thinking in this young but important field.

Human beings interact with other human beings in somewhat the same way they interact with nonhuman and nonliving stimuli. But there is a significant difference in that interpersonal actions involve a second human being (or more) who also exhibits psychological characteristics. Interpersonal behavior is therefore more complex than is that between a person and an inanimate stimulus. Furthermore, groups of people create conditions such as laws, customs, and institutions, with which the individual interacts. Social psychology is that special field in which the psychologist devotes himself to the discovery of causal variables in the social situation or the social institution. In a sense, then, this endeavor complements the program of physiological psychology.

The disciplines known as the social sciences — sociology, political science, history, economics, anthropology — are concerned primarily with those phenomena created by groups. They seek to understand how customs, mores, taboos, institutional ways, culture, wealth, social movements and other examples of group action originate, how they become modified, and, frequently, how they affect human welfare. For the social psychologist the primary focus is on the behavior of the person as the fundamental unit of a group, whereas for representatives of the other disciplines the entire group is usually the unit. But there is no sharp dividing line in the work of the social psychologist and the sociologist or the anthropologist. Indeed, these three disciplines have all but merged on many problems of mutual interest.

It has been said that all psychology is social psychology to some degree. Even though we may appear to have much psychological business with inanimate stimuli, other human beings or cultural products influence nearly everything we do. We feed ourselves to satisfy a biological urge, but the way we do it, and to some extent the food we choose, is the result of the culture in which we were raised. We perceive others in terms of the role they seem to play within the social scheme and we tend to evaluate them against social standards. Personality is to a large degree the pattern of adjustive behavior within a given social structure. Child development includes the process of becoming socialized or of learning the value of some conformity with the group. These few examples illustrate the significance of social phenomena.

Social psychologists have been especially active in the study of group processes, social communication, leadership, attitudes and prejudices, group action, group organization, and social stress. Part VIII includes three articles dealing with trends in modern research and three articles having to do with theory. Argyle reviews a number of well-known studies on group leadership and the development of group norms or expectations for those comprising the group. Asch describes and interprets his famous experiments on the modification of perceptual responses by group pressure. Then Chapin illustrates some field-study methods by giving accounts of the effect of social changes on the personal adjustment of individuals. Murdock describes an interdisciplinary research program built upon a theory of personality as the result of resolving conflicts between inherited impulses and learned social demands. Montagu stresses the environmentalist's interpretation of human nature. In the last selection, Henry critically evaluates the application of the physiological principle of homeostasis to interpersonal and intergroup phenomena.

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The Study of Social Behaviour

MICHAEL ARGYLE

In this selection, a British psychologist discusses some examples of experimental-social research conducted by psychologists in the United States. He points out that the program of such research is to develop widely applicable generalizations about group processes, then test their validity by determining how they apply to new situations. In these studies the experimenters attempted to bring naturalness into the laboratory where they had good control over the conditions. Along with selection 53 by Asch, these investigations should be contrasted with the field studies described by Chapin in selection 54. Control of extraneous factors is rarely as tight as is desired when one works in the field, but the advantage is that naturalness is enhanced. Argyle points out that one value of theorizing is to make predictions, and he illustrates this principle with some predictions or hypotheses about delinquency.

Michael Argyle is lecturer in social psychology at the University of Oxford. The selection which follows was originally one of a series of talks on the BBC Third Programme broadcasts. It also appeared as Chapter 5 in *Experimental Psychology*, edited by B. A. Farrell and published at Oxford in 1955 by Basil Blackwell, who gave permission for its use here.

Social behaviour has traditionally been the province of the novelist and the sage: to-night I am going to tell you something of the contribution of the social psychologist. During the last few years the methods of experimental psychology have come to be applied to the study of social behaviour, both by setting up complete experimental situations and experimental social groups, and by statistical investigations of social behaviour in the field. All kinds of social behaviour have become the subjects of research — the complex give-and-take between two people during an interview, the development of the child's personality in the family, the rise of tensions, and conflicts inside social organizations. I am going to say something about a field in social psychology that is intimately bound up with everyday life. This is the study of small social groups, such as work-teams, clubs, committees, and groups of friends. Over 150 experiments have now been reported in the literature (*1*), most of them since the war: I shall only have time to mention two sets of these. The first is concerned with the establishment of valid generalizations, or laws, about social behaviour, which can be used with confidence as the basis for predictions. The second set represents an attempt to discover the explanation for established generalizations by postulating a deductive theory. These are the two principal aims of the experimental psychologist — to establish valid generalizations about behaviour, and then to explain them.

The first series of experiments deals with the effect of different kinds of imposed leader, or supervisor, on the behaviour of small groups. One of the classic experiments here was carried out by Lippitt (2) at the University of Iowa in 1938–9. Several groups of five boys, equally matched as far as possible, were formed into what were, from the point of view of the boys, real clubs for making masks. The experimental variable that was introduced consisted of two contrasted styles of behaviour on the part of the club leaders. The so-called 'autocratic' leaders gave orders, often opposed the wishes of the boys, and gave personal and frequently adverse criticism. The 'democratic' leaders, on the other hand, allowed the group to decide among themselves what they were to do, and simply gave suggestions and information. All the groups experienced both kinds of treatment in turn. The behaviour of the groups was recorded by a number of unobtrusive observers who were introduced to the boys as 'some people who are interested in seeing how a good club runs,' and who were quickly ignored. They kept a continuous record of interpersonal behaviour within the groups, and it was found that the democratically-led groups were more friendly among themselves and that unlike the autocratic groups, they worked when the leader was out of the room. Under the autocratic leader, on the other hand, the groups were discontented and often aggressive, and there was a tendency to 'scapegoat' individual members. This experiment has attracted a good deal of interest on account of its political implications, but it must be emphasized that the results cannot be applied to larger groups, larger boys, or to other cultures. The importance of this experiment for us is the introduction of certain new experimental techniques to the study of social behaviour — the setting up of matched and realistic groups, the systematic recording of social behaviour, and the use of leaders who had been trained in experimentally contrasted patterns of behaviour.

A part of Lippitt's conclusions was later put to practical use; several subsequent field experiments showed that the use of group decisions — part of the democratic style of leadership — can be a powerful means of influencing people's behaviour. The best way of persuading American housewives to eat brown bread during the war was to get them to decide to do so in groups, as opposed to browbeating individuals or arranging lectures on dietetics (3). Industrial changes have been brought about in a similar way (*4*).

The explanation of these phenomena will become clearer later — the pressures exerted by a group on its members are stronger than most other forces which can be brought to bear upon them.

There is another group of industrial studies which bears out the results of the Lippitt experiment. These were performed by Katz (5) of the University of Michigan and were concerned with the influence of the behaviour of supervisors on the productivity and satisfaction of work-teams. Out of 180 work-teams on the Chesapeake and Ohio Railway, forty pairs of teams were selected so that those in each pair were equivalent for the type and conditions of work on their sections of track. Inspectors then decided which of each pair had the higher output, while interviews with the men showed which team had the greater satisfaction in their work. The behaviour and attitudes of foremen were then found by interviewing *them.* It was found that there was higher output and greater satisfaction in teams whose foremen spent more time actually supervising, but who supervised less closely and took an interest in their men in such ways as training them for promotion. I should stress that this was not an experiment proper, but a field study in which the co-variation of two factors over a number of groups was studied. While this design has the advantage that all artificiality is avoided, it is sometimes difficult to know which is cause and which effect.

The results obtained on the Chesapeake and Ohio Railway were also found in a Caterpillar Tractor factory and in an Insurance company; similar results have also been obtained at a high level of industry. This type of study is, of course, of immense practical importance since the results can, for example, be used for designing training courses for foremen — though that presents a further range of practical problems about the effectiveness of various kinds of course. As I've said, it is dangerous to attempt to apply any of these conclusions outside the context in which they were obtained. On the other hand, these particular findings have received fairly wide confirmation in American industry, and it is hoped to be able to confirm some of them in the course of an investigation in this country.

This is only one example of the kind of generalization which is being established by social psychologists: many others could be quoted. These investigations may be contrasted with an early study of a work-team, usually known as the 'Hawthorne Experiment,' which was carried out under the direction of Elton Mayo. Five girls, who were assembling telephone relays, were continuously observed for five years from 1927–32 in a special test room, while various experimental changes were introduced. The girls were given shorter hours: the rate of output went up. They were given rest periods: the output again went up. Then they were returned to the original conditions: output still went up. This is the stock classroom joke of the industrial psychologist, the widely-publicized conclusion being that the increased output was due to the girls' improved relationship with their supervisors. As a matter of fact it is quite impossible to draw this or any other conclusion. Compare the set-up of this experiment with the Chesapeake and Ohio investigation. In that study Katz discovered statistical greater-than-chance effects over eighty groups, whereas in the Hawthorne experiment there was only one group which was subject to all kinds of random influences — for example, one of the girls had to support a large family and encouraged the other girls to work hard in order to increase her pay on group piece-work. Secondly, while the work teams on the railway were quietly studied while at their usual work, the Hawthorne girls were under the eye of streams of managers, professors and psychologists, and they knew that the aim of the investigation was to increase output. Incidentally, two of the girls who did not increase were replaced. Katz's was a carefully-designed investigation in which groups differing only in respect of leadership were compared, and their satisfaction and output measured in a refined manner. Methods of measurement and research have been very highly developed since the days of the Hawthorne experiment (6).

The second group of experiments I shall discuss has a rather different aim from those described so far. In this case the basic phenomenon was well known: social psychologists were interested, not in its confirmation, but in its explanation. When an empirical law has been established the further question arises 'Why does this happen?' to which the scientific answer is generally to bring forward a set of postulates from which the empirical law can be derived. It has been pointed out in previous broadcasts in this series that a generalization in experimental psychology can often be explained by deducing it from known or hypothetical physiological mechanisms. We might expect, therefore, that group phenomena could be deduced from actual or hypothetical psychological processes in individuals, and this is precisely what is done.

It has long been familiar to sociologists that groups develop shared patterns of behaviour and belief, often called 'Norms.' Work-teams develop norms about the amount of work that shall be done — and may enforce restriction of output on their members; Chicago gangs had very rigid codes of behaviour, albeit somewhat different from those followed by the rest of the public; even psychologists have norms about what constitutes a satisfactory experiment. The existence of norms is widely established, but why are they formed? Several very ingenious laboratory experiments have been carried out which throw some light on this problem. These experiments were all performed in the laboratory under somewhat artificial conditions, so that variable factors could be manipulated and controlled more easily, but this has led to a number of predictions which are relevant to life outside the laboratory.

The first of these experiments was done by Sherif (7) in 1935; he made use of the fact that a spot of light in a dark room seems to move about; pairs of people in a dark room were asked to make judgments about how far a light had been moved — the light being in fact stationary. After a time the pairs of people began to make the same kind of judgments about the light; this was regarded by Sherif as a perceptual norm set up as a result of the judgments of the other acting as a background for the perception of the vague stimulus itself. Sherif thought that all norms were set up by such changes in perception, but other experiments show that his interpretation is untenable.

In a recent experiment by Asch (8), subjects had to match a given line in length with one of three other lines, by just looking at the lines in the presence of a group of people, all of whom were confederates of the experimenter and who unanimously gave the wrong answer. Many of the genuine subjects yielded to the majority in this situation. Interviewing disclosed that very few subjects experienced any *perceptual* distortion here, but simply altered their verbal reports in order not to look silly. This experiment shows that a perceptual change is not necessary for norm-formation to occur. A third experiment by Thomas Coffin (9) indicates the probable role of perception in these situations. Subjects were allowed to read fake offprints from a scientific periodical: half of them read an article saying that people with high intelligence responded to *details* of the Rorschach ink-blot test, the other half read that intelligent people reacted to the form of the blots as a *whole*. The subjects were then given the Rorschach test, and it was found that the first batch saw details while the second saw wholes. This demonstrates that perceptions can be achieved as a result of consciously directed effort. In all these experiments what people *said* was influenced in every case: what they *see* may also be affected if the situation is sufficiently ambiguous, but it is clearly not an essential factor.

Another approach to the problem of norm-formation was tried by Leon Festinger (*10*) and his collaborators four years ago. They set up discussion groups in which the members were asked to come to some agreement about problems on which they initially disagreed. It appeared that at first all discussion was directed towards the people with extreme views, but that if they failed to change their minds the others ceased to communicate with them. It was also found that such deviates became rejected by the group, as shown by various questionnaire measures. For our purposes the interesting conclusion is that deviates are rejected. This result was also obtained in a field study of a housing estate.

From this, some suggestions may be offered for a psychological explanation of norm-formation. Other studies have shown that there is a universal social need for acceptance, rather like the biological need for food. This need is focused on particular individuals and groups, just as the hunger drive only operates for certain kinds of food. Social needs, however, are probably learnt in childhood. If it is assumed that previous groups to which a person has belonged rejected deviates, it follows that conforming to norms will have been rewarded by acceptance and deviation punished by rejection, so that conforming becomes a learnt act. It is not supposed that this is the only process involved in norm-formation — for instance, there is selection for membership of groups so that people are similar before they join — but it is one process which does seem to be at work. Furthermore, it is possible to make a number of predictions from these hypotheses, and that is the main purpose of theorizing.

It would be expected, for example, that social pressures would be quite ineffective when what a person does cannot be checked up on by those exerting the pressure. I confirmed this prediction in an experiment in which subjects were exposed to a standard amount of persuasion to change their judgment about a certain work of art. In one experimental condition the subjects informed the person who had been arguing with them about their final opinion; in the other condition they expressed it on a form which they placed in a sealed envelope which would never be connected with them personally. It was found that there was considerable influence with the face-to-face denouement and virtually none in the sealed envelope condition.

If delinquents are regarded as deviants from society, it may be supposed that the learning of conforming behaviour has broken down at some point. It may be through lack of the need for acceptance — as is possibly the case with psychopaths; it may be a result of membership of deviant groups — as is certainly the case with many; it may be because rejection of deviates was not practised in their early social milieu, though this is unlikely; finally it may be through lack of skill at interpreting social situations. These types of delinquents would be open to treatment in quite different ways.

I have given a sample only from a limited field of what social psychologists are doing. There are other ways of approaching social behaviour — for example, it can be explained by reference to the conscious experiences that accompany behaviour, the way of common sense. Again it can be approached from the point of view of the psychoanalyst, who makes interpretations of people's unconscious motivation in order to account for their behaviour. I suggest that the scientific and experimental way has two great advantages over these others. In the first place it really does lead to the establishment of empirical laws which can be put to practical use — as for example Katz's results can be used in the training of foremen. Secondly, it leads to the development of systematic deductive theories, which not only summarize existing knowledge and suggest new research, but also enable us to understand why people behave as they do.

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Opinions and Social Pressure

SOLOMON E. ASCH

It is a rather common observation that the behavior of an individual is considerably influenced by group pressure or authority, even when the influence is subtle or indirect. Such effect is particularly striking when the behavior involves judgments or opinions on controversial issues. Recent experimental research by social psychologists, of which this selection is an example, shows that interpersonal influences affect the way we perceive simple visual stimuli, or at least the way we *say* we perceive them. These studies reported by Asch illustrate again how a problem can be narrowed down by a series of studies (a research program) to give a more complete understanding of the factors involved. They also show how research points up new problems for further investigation, while it answers some of the initial questions.

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That social influences shape every person's practices, judgments and beliefs is a truism to which anyone will readily assent. A child masters his "native" dialect down to the finest nuances; a member of a tribe of cannibals accepts cannibalism as altogether fitting and proper. All the social sciences take their departure from the observation of the profound effects that groups exert on their members. For psychologists, group pressure upon the minds of individuals raises a host of questions they would like to investigate in detail.

How, and to what extent, do social forces constrain people's opinions and attitudes? This question is especially pertinent in our day. The same epoch that has witnessed the unprecedented technical extension of communication has also brought into existence the deliberate manipulation of opinion and the "engineering of consent." There are many good reasons why, as citizens and as scientists, we should be concerned with studying the ways in which human beings form their opinions and the role that social conditions play.

Studies of these questions began with the interest in hypnosis aroused by the French physician Jean Martin Charcot (a teacher of Sigmund Freud) toward the end of the 19th century. Charcot believed that only hysterical patients could be fully hypnotized, but this view was soon challenged by two other physicians Hyppolyte Bernheim and A. A. Liébault, who demonstrated that they could put most people under the hypnotic spell. Bernheim proposed that hypnosis was but an extreme form of a normal psychological process which became known as "suggestibility." It was shown that monotonous reiteration of instructions could induce in normal persons in the waking state involuntary bodily changes such as swaying or rigidity of the arms, and sensations such as warmth and odor.

It was not long before social thinkers seized upon these discoveries as a basis for explaining numerous social phenomena, from the spread of opinion to the formation of crowds and the following of leaders. The sociologist Gabriel Tarde summed it all up in the aphorism: "Social man is a somnambulist."

When the new discipline of social psychology was born at the beginning of this century, its first experiments were essentially adaptations of the suggestion demonstration. The technique generally followed a simple plan. The subjects, usually college students, were asked to give their opinions or preferences concerning various matters; some time later they were again asked to state their choices, but now they were also informed of the opinions held by authorities or large groups of their peers on the same matters. (Often the alleged consensus was fictitious.) Most of these studies had substantially the same result: confronted with opinions contrary to their own, many subjects apparently shifted their judgments in the direction of the views of the majorities or the experts. The late psychologist Edward L. Thorndike reported that he had succeeded in modifying the esthetic preferences of adults by this procedure. Other psychologists reported that people's evaluations of the merit of a literary passage could be raised or lowered by ascribing the passage to different authors. Apparently the sheer weight of numbers or authority sufficed to change opinions, even when no arguments for the opinions themselves were provided.

Now the very ease of success in these experiments arouses suspicion. Did the subjects actually change their opinions, or were the experimental victories scored only on paper? On grounds of common sense, one must question whether opinions are generally as watery as these studies indicate. There is some reason to wonder whether it was not the investigators who, in their enthusiasm for a theory, were suggestible, and whether the ostensibly gullible subjects were not providing answers which they thought good subjects were expected to give.

The investigations were guided by certain underlying assumptions, which today are common currency and account for much that is thought and said about the operations of propaganda and public opinion. The assumptions are that people submit uncritically and painlessly to external manipulation by suggestion or prestige, and that any given idea or value can be "sold" or "unsold" without reference to its merits. We should be skeptical, however, of the supposition that the power of social pressure necessarily implies uncritical submission to it: independence and the capacity to rise above group passion are also open to human beings. Further, one may question on psychological grounds whether it is possible as a rule to change a person's judgment of a situation or an object without first changing his knowledge or assumptions about it.

In what follows I shall describe some experiments in an investigation of the effects of group pressure which was carried out recently with the help of a number of my associates. The tests not only demonstrate the operations of group pressure upon individuals but also illustrate a new kind of attack on the problem and some of the more subtle questions that it raises.

A group of seven to nine young men, all college students, are assembled in a classroom for a "psychological experiment" in visual judgment. The experimenter informs them that they will be comparing the lengths of lines. He shows two large white cards. On one is a single vertical black line — the standard whose length is to be matched. On the other card are three vertical lines of various lengths. The subjects are to choose the one that is of the same length as the line on the other card. One of the three actually is of the same length; the other two are substantially different, the difference ranging from three quarters of an inch to an inch and three quarters.

The experiment opens uneventfully. The subjects announce their answers in the order in which they have been seated in the room, and on the first round every person chooses the same matching line. Then a second set of cards is exposed; again the group is unanimous. The members appear ready to endure politely another boring experiment. On the third trial there is an unexpected disturbance. One person near the end of the group disagrees with all the others in his selection of the matching line. He looks surprised, indeed incredulous, about the disagreement. On the following trial he disagrees again, while the others remain unanimous in their choice. The dissenter becomes more and more worried and hesitant as the disagreement continues in succeeding trials; he may pause before announcing his answer and speak in a low voice, or he may smile in an embarrassed way.

What the dissenter does not know is that all the other members of the group were instructed by the experimenter beforehand to give incorrect answers in unanimity at certain points. The single individual who is not a party to this pre-arrangement is the focal subject of our experiment. He is placed in a position in which, while he is actually giving the correct answers, he finds himself unexpectedly in a minority of one, opposed by a unanimous and arbitrary majority with respect to a clear and simple fact. Upon him we have brought to bear two opposed forces: the evidence of his senses and the unanimous opinion of a group of his peers. Also, he must declare his judgments in public, before a majority which has also stated its position publicly.

The instructed majority occasionally reports correctly in order to reduce the possibility that the naïve subject will suspect collusion against him. (In only a few cases did the subject actually show suspicion; when this happened, the experiment was stopped and the results were not counted.) There are 18 trials in each series, and on 12 of these the majority responds erroneously.

How do people respond to group pressure in this situation? I shall report first the statistical results of a series in which a total of 123 subjects from three institutions of higher learning (not including my own, Swarthmore College) were placed in the minority situation described above.

Two alternatives were open to the subject: he could act independently, repudiating the majority, or he could go along with the majority, repudiating the evidence of his senses. Of the 123 put to the test, a considerable percentage yielded to the majority. Whereas in ordinary circumstances individuals matching the lines will make mistakes less than 1 per cent of the time, under group pressure the minority subjects swung to acceptance of the misleading majority's wrong judgments in 36.8 per cent of the selections.

Of course individuals differed in response. At one extreme, about one quarter of the subjects were completely independent and never agreed with the erroneous judgments of the majority. At the other extreme, some individuals went with the majority nearly all the time. The performances of individuals in this experiment tend to be highly consistent. Those who strike out on the path of independence do not, as a rule, succumb to the majority even over an extended series of trials, while those who choose the path of compliance are unable to free themselves as the ordeal is prolonged.

The reasons for the startling individual differences have not yet been investigated in detail. At this point we can only report some tentative generalizations from talks with the subjects, each of whom was interviewed at the end of the experiment. Among the independent individuals were many who held fast because of staunch confidence in their own judgment. The most significant fact about them was not absence of responsiveness to the majority but a capacity to recover from doubt and to re-establish their equilibrium. Others who acted independently came to believe that the majority was correct in its answers, but they continued their dissent on the simple ground that it was their obligation to call the play as they saw it.

Among the extremely yielding persons we found a group who quickly reached the conclusion: "I am wrong, they are right." Others yielded in order "not to spoil your results." Many of the individuals who went along suspected that the majority were "sheep" following the first responder, or that the majority were victims of an optical illusion; nevertheless, these suspicions failed to free them at the moment of decision. More disquieting were the reactions of subjects who construed their difference from the majority as a sign of some general deficiency in themselves, which at all costs they must hide. On this basis they desperately tried to merge with the majority, not realizing the longer-range consequences to themselves. All the yielding subjects underestimated the frequency with which they conformed.

Which aspect of the influence of a majority is more important — the size of the majority or its unanimity? The experiment was modified to examine this question. In one series the size of the opposition was varied from one to 15 persons. The results showed a clear trend. When a subject was confronted with only a single individual who contradicted his answers, he was swayed little: he continued to answer independently and correctly in nearly all trials. When the opposition was increased to two, the pressure became substantial: minority subjects now accepted the wrong answer 13.6 per cent of the time. Under the pressure of a majority of three, the subjects' errors jumped to 31.8 per cent. But further increases in the size of the majority apparently did not increase the weight of the pressure substantially. Clearly the size of the opposition is important only up to a point.

Disturbance of the majority's unanimity had a striking effect. In this experiment the subject was given the support of a truthful partner — either another individual who did not know of the pre-arranged agreement among the rest of the group, or a person who was instructed to give correct answers throughout.

The presence of a supporting partner depleted the majority of much of its power. Its pressure on the dissenting individual was reduced to one fourth: that is, subjects answered incorrectly only one fourth as often as under the pressure of a unanimous majority. The weakest persons did not yield as readily. Most interesting were the reactions to the partner. Generally the feeling toward him was one of warmth and closeness; he was credited with inspiring confidence. However, the subjects repudiated the suggestion that the partner decided them to be independent.

Was the partner's effect a consequence of his dissent, or was it related to his accuracy? We now introduced into the experimental group a person who was instructed to dissent from the majority but also to disagree with the subject. In some experiments the majority was always to choose the worst of the comparison lines and the instructed dissenter to pick the line that was closer to the length of the standard one; in others the majority was consistently intermediate and the dissenter most in error. In this manner we were able to study the relative influence of "compromising" and "extremist" dissenters.

Again the results are clear. When a moderate dissenter is present, the effect of the majority on the subject decreases by approximately one third, and extremes of yielding disappear. Moreover, most of the errors the subjects do make are moderate, rather than flagrant. In short, the dissenter largely controls the choice of errors. To this extent the subjects broke away from the majority even while bending to it.

On the other hand, when the dissenter always chose the line that was more flagrantly different from the standard, the results were of quite a different kind. The extremist dissenter produced a remarkable freeing of the subjects; their errors dropped to only 9 per cent. Furthermore, all the errors were of the moderate variety. We were able to conclude that dissent *per se* increased independence and moderated the errors that occurred, and that the direction of dissent exerted consistent effects.

In all the foregoing experiments each subject was observed only in a single setting. We now turned to studying the effects upon a given individual of a change in the situation to which he was exposed. The first experiment examined the consequences of losing or gaining a partner. The instructed partner began by answering correctly on the first six trials. With his support the subject usually resisted pressure from the majority: 18 of 27 subjects were completely independent. But after six trials the partner joined the majority. As soon as he did so, there was an abrupt rise in the subjects' errors. Their submission to the majority was just about as frequent as when the minority subject was opposed by a unanimous majority throughout.

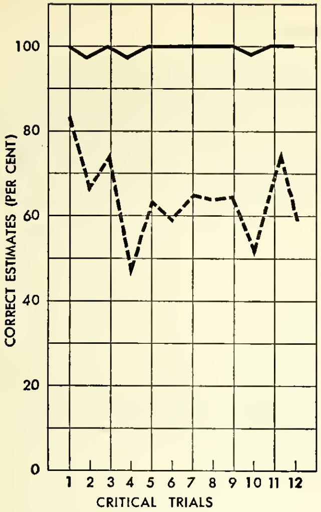
It was surprising to find that the experience of having had a partner and of having braved the majority opposition with him had failed to strengthen the individuals' independence. Questioning at the conclusion of the experiment suggested that we had overlooked an important circumstance; namely, the strong specific effect of "desertion" by the partner to the other side. We therefore changed the conditions so that the partner would simply leave the group at the proper point. (To allay suspicion it was announced in advance that he had an appointment with the dean.) In this form of the experiment the partner's effect outlasted his presence. The errors increased after his departure, but less markedly than after a partner switched to the majority.

In a variant of this procedure the trials began with the majority unanimously giving correct answers. Then they gradually broke away until on the sixth trial the naïve subject was alone and the group unanimously against him. As long as the subject had anyone on his side, he was almost invariably independent, but as soon as he found himself alone, the tendency to conform to the majority rose abruptly.

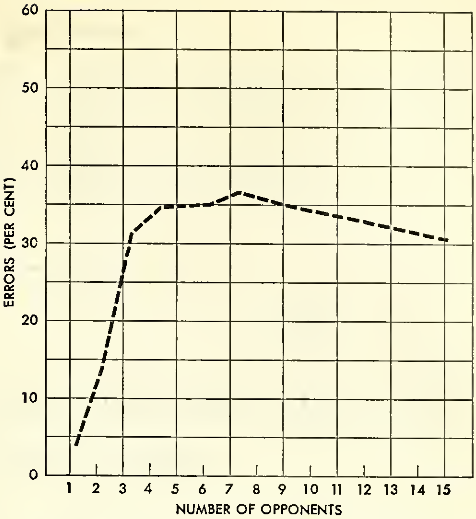
As might be expected, an individual's resistance to group pressure in these experiments depends to a considerable degree on how wrong the majority is. We varied the discrepancy between the standard line and the other lines systematically, with the hope of reaching a point where the error of the majority would be so glaring that every subject would repudiate it and choose independently. In this we regretfully did not succeed. Even when the difference between the lines was seven inches, there were still some who yielded to the error of the majority.

The study provides clear answers to a few relatively simple questions, and it raises many others that await investigation. We would like to know the degree of consistency of persons in situations which differ in content and structure. If consistency of independence or conformity in behavior is shown to be a fact, how is it functionally related to qualities of character and personality? In what ways is independence related to sociological or cultural conditions? Are leaders more independent than other people, or are they adept at following their followers? These and many other questions may perhaps be answerable by investigations of the type described here.

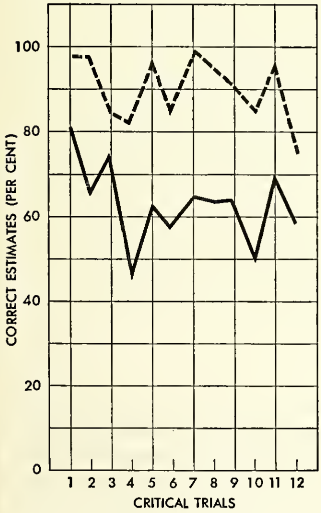
Life in society requires consensus as an indispensable condition. But consensus, to be productive, requires that each individual contribute independently out of his experience and insight. When consensus comes under the dominance of conformity, the social process is polluted and the individual at the same time surrenders the powers on which his functioning as a feeling and thinking being depends. That we have found the tendency to conformity in our society so strong that reasonably intelligent and well-meaning



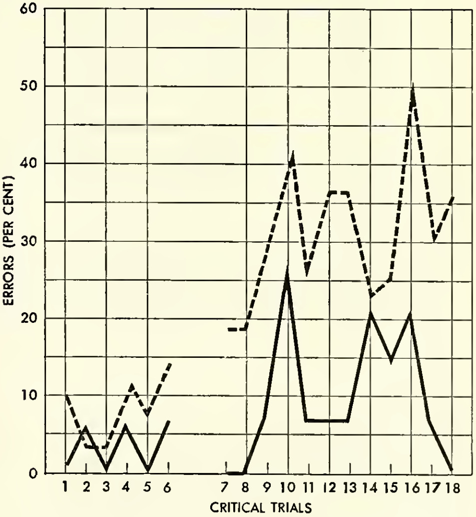
1. Error of 123 subjects, each of whom compared lines in the presence of six to eight opponents, is plotted in the broken curve. The accuracy of judgments not under pressure is indicated bv the salid curve.



2. Size of majority which apposed them had an effect on the subjects. With a single apponent the subject erred anly 3.6 per cent of the time; with two opponents he erred 13.6 per cent; three, 31.8 per cent; faur, 35.1 per cent; six, 35.2 per cent; seven, 37.1 per cent; nine, 35.1 per cent; fifteen, 31.2 per cent.



3. Two subjects supporting each other against a majority made fewer errors (broken curve) than one subject did against a majority (solid curve).



4. Partner left subject after six trials in a single experiment. The broken curve shows the error of the subject when the partner "deserted" to the majority. Solid curve shows error when partner merely left the room.

young people are willing to call white black is a matter of concern. It raises questions about our ways of education and about the values that guide our conduct.

Yet anyone inclined to draw too pessimistic conclusions from this report would do well to remind himself that the capacities for independence are not to be underestimated. He may also draw some consolation from a further observation: those who participated in this challenging experiment agreed nearly without exception that independence was preferable to conformity.

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The Experimental Method in the Study of Human Relations

F. STUART CHAPIN

The author of this selection is interested in the influence of socio-environmental factors on adjustments of individuals and improved human relations. He is especially concerned with the development of methods of studying such effects and points out the differences between designs for field studies and those for experimental laboratory investigations. The studies which he reviews, conducted in the "free community setting," indicate the possibilities and limitations of the cross-sectional, projected, and ex post facto types of experimental design. Notice the emphasis he gives to replication of research as one way to obtain validation. The behavior scientist is not content to accept opinions that changed environmental conditions or social reform will produce improved human relations; he knows that objective evidence is more dependable. The studies which Chapin describes in general provide supporting evidence, and he believes that future developments of methods will be capable of revealing clearly cause-effect evidence.

Dr. Chapin, a research consultant, is an authority on investigative methods in the social sciences. For many years he was director of the School of Social Work at the University of Minnesota and has also been a member of the faculty at Wellesley and at Smith. This article appeared in February, 1949, in *Scientific Monthly* (pp. 132–139), and is reprinted by permission of the publisher and the author.

In 1916 I wrote an article on this subject which was published in *The Scientific Monthly* of February–March, 1917. It may be of interest, after thirty years, to review briefly the development of experimental designs applied to the study of human relations.

The experimental study of human relations in the free community can hardly be reduced to laboratory conditions of control. Hence the present article will exclude all experimental studies conducted in an artificial or classroom situation and confine attention to six illustrative studies that were made in the free community situation. This limitation has the advantages of distinguishing sharply, first, the fundamental principle that controlled observation relies on the matching of measurements rather than on physical manipulation; and, second, the kinds of practical obstacles encountered in all attempts at controlled observation in the free community situation. The six studies to be described are all published and show how systematic efforts were made to control variable factors by matching on measurements between an experimental group that received some social program and a control group denied this program.

In the interest of clear thinking about this problem it is helpful to distinguish, first, the trial-and-error "experiments" of social legislation as a means to achieve some desired end (public housing as a means to improve the adjustment of low-income families); second, the operations of natural social forces that produce an effect; and, third, the use of experimental designs as a method of study of the first two, in order to determine the degree of success in the attainment of a desired social end, or to measure the effect of some social force. Since a social reform program is a social force that operates according to some plan of action, our description will be confined to illustrations of this, the first of the foregoing distinctions, rather than illustrations of the use of experimental designs in the study of unplanned consequences of combinations of independently planned social actions, which is the second type distinguished above. This second type would take us too far afield, since it concerns the phenomena of conflict among the means-ends scheme of special interest groups, a resulting composition of social forces, and the emergence of unplanned consequences which plague the authors and the leaders of the component but independently planned programs. Business cycles, inflation, mass movements, etc., are examples of this second type. Such mass behavior can hardly be studied experimentally until we have solved some of the problems connected with experimental study of their simpler component means-ends relations. Hence the limitation noted above.

Five methods of observation and analysis are essential in studies of human relations by experimental designs: social measurements by use of standardized psychometric or sociometric scales; random samples or a stratified random sample; control of observations by matching on social measurements; use of the null hypothesis; and qualified application of the principle of probability.

Leaders of social reform have often found that the ends they desired to achieve by means of legislation are seldom fully attained, usually because they are unexpected results which flow from the unplanned combinations of other independently planned social actions. In the free community situation of a democratic social order, it is customary to protect the rights of minority groups (political, religious, and social) in freedom of assemblage, freedom of speech, freedom of religious worship, etc. The consequences of these democratic freedoms are that many special-interest groups in society set up their own means-ends schema and work at cross-purposes to other minorities to achieve their contradictory goals. These phenomena take the familiar forms of social tensions, group conflicts, achievement of one at the expense of the frustration of the other, etc., all of which appear to the foreign observer as evidences of internal confusion and mislead such observers about the existence of a deep current of agreement on essentials. This web of human relations fluctuates within certain limits of social elasticity, now seemingly stretched to the breaking point, and then contracting again to a more stable social structure. How can one ever untangle the separate strands of this complex social fabric? Although adequate answers to this question await the study by experimental designs, or by other methods of analysis, of the involved chain of causes and effects now hidden in the unplanned consequences that arise out of combinations of independently planned social actions, it can be shown that a real beginning has been made at a simpler level in the study of particular cause-and-effect sequences which are called the means-ends schema of social reform. The beginning is real because it is based upon concrete studies of social facts and not on armchair social philosophy; it is promising because the method of experimental design has now been used with moderate success in tests of such problems as direct relief versus work relief, public housing, and juvenile delinquency; it is objective because the method is susceptible of repetition by equally competent observers who use quantitative descriptions of human relations.

Despite some modest development in experimental designs, my present concern is with the still-unsolved problems of the method, so that the difficulties to be overcome may not be lost sight of in an account of some undoubted achievements.

There are three general patterns of experimental design in the study of human relations in the free community situation: first, a cross-sectional design in which comparison is made for a given date between an experimental group which receives a social program, and a matched control group denied this program; second, a projected design in which before and after measurements are made upon an experimental group which received a program over an interval of time, and a matched control group denied this program; and, third, what may be called the ex post facto design, in which a present situation is taken as an effect of some assumed and previously operating causal complex of factors, and, depending upon the adequacy of accessible records, an experimental group and a matched control group are traced back to an earlier date when the force to be measured began functioning upon the experimental group but not upon the control group.

CROSS–SECTIONAL EXPERIMENTAL DESIGN

Nathan Mandel used this method in a study of the Boy Scout program and the measured personal adjustment of boys. It is at once evident that some measures of personal adjustment that are reliable and valid will be required, and also some measures of other factors to be controlled, in order that the real association between the Scout program (the means, or causal variable) and the personal adjustment (the end, or effect variable) may be described. The three measures of adjustment used were the Bell *Adjustment Inventory*, Rundquist and Sletto's *Morale* and *General Adjustment* scales (all measures of how the individual feels), and the Chapin *Social Participation Scale* (a measure of overt activity in organized groups).

Choosing every tenth case in the file of 2,050 Boy Scouts in the 1934 "drop-out" file of the Minneapolis area yielded a total of 205 boys. Only 102 of these were found and interviewed in 1938. Since 103 had moved away, could not be located, would not cooperate, or were deceased, the residual sample ceased to be random. The remaining 102 cases were divided into two groups, an experimental group whose training had lasted 4 years on the average, and a control group with an average tenure of 1.3 years. When these were matched on four available traits in the record (birthplace, urban or rural, father's occupation, health rating, and school age-grade ratio), there was a further shrinkage of 22 cases, so that the final totals were 40 in each group.

It was found that the 4-year Scouts were slightly better adjusted on both the Bell and the Rundquist-Sletto scales than the control group of drop-outs. Interpretation of these results as indicative of mere conformity and conventionality rather than of somewhat better integration of personality would then have to explain why it was that the drop-outs showed higher scores on the Chapin *Social Participation Scale* than did the 4-year Scouts, since a higher social participation score is evidence against the rejection from membership of the drop-outs by the organized groups in which they were active. All in all, this study was somewhat inconclusive, since the advantage evidenced by higher adjustment scores of the 4-year Scouts was too slight to provide local proof of the hypothesis upon which the Scout program is based; but the results were at least consistent with the expectations implicit in the Boy Scout program.

During the great depression of the 1930's it became evident that material relief alone was a mere stop-gap, and that self-respecting assistance to the unemployed should take the form of a work-relief program. Hence the Works Progress Administration was undertaken. It was claimed that the WPA would develop morale and maintain it more effectively than a direct-relief program of material assistance.

To test the validity of this claim an experimental design study was made in St. Paul, Minnesota, in 1939. A total of 465 cases were on direct relief in March of that year, and 8,074 persons were on WPA. A 5 percent random sample of these WPA cases, or 412 persons, was taken as an experimental group to be compared with the 465 relief clients. To make these groups sufficiently homogeneous for valid comparison, seven conditions were set: living in St. Paul; working in Ramsey County; not previously on WPA; and not single, widowed, separated, or divorced. Meeting these conditions reduced the WPA experimental group to 324 cases, and the control group of relief clients to 198. These 522 cases were interviewed in April–May and the total still further reduced by 320 cases because of refusals, could not be located, had moved away, deceased, sickness, gainfully employed, changed status, etc. As a result there remained 130 cases in the experimental group of WPA and only 72 direct-relief clients. These two groups were then matched on seven factors: age, sex, race, nativity, years of formal education, usual occupation, and size of family. Had this matching on traits not been done the obtained variations in measured morale and adjustment might have been due to one or more of these factors, rather than associated with being on WPA or on direct relief, the association we set out to measure. Again, both groups lost cases because unable to match, so that the terminal groups consisted of an experimental group of 80 WPA matched on seven factors against a control group of 42 on direct relief.

During the interviews every individual was measured for his morale and his general adjustment score on the Rundquist-Sletto scales, and for social participation and social status on the Chapin scales. On each of these scales the WPA group showed better average measures of adjustment than did the relief group. Differences between these average group scores were, however, not statistically significant, so that chance could account for the differences. But the differences were in the expected direction, and a measure of all four in combination as a pattern of response to differential treatment by the two contrasting programs showed that these differences in pattern could occur by chance somewhere between 1 in 10 and 1 in 50. Again, our experimental design study failed to yield positive proof of a hypothesis of high association, although it did yield results not contrary to this hypothesis.

To summarize the most significant findings from these two examples of cross-sectional experimental design, it may be noted:

1. That no test of cause and effect or of concomitant variation is possible by this method; the only evidence obtained is that of an *association* at a given date between two factors (different programs of assistance on the one hand, and measured adjustment on the other), but this association was in the expected direction, if it is assumed that WPA is superior to direct relief in attaining better adjustment.
2. The enormous losses of cases owing to selective conditions in the natural community, plus losses from matching, destroyed any randomness of the original samples, and increased the magnitude of the standard errors, thus reducing the statistical significance of any differences obtained.
3. Since the residual groups departed from randomness, no generalization can be made from such studies to any larger universe or universes from which the groups were taken, although it remains true that conclusions for the limited groups studied do have a valid basis in fact.

PROJECTED EXPERIMENTAL DESIGN

Unless social cause and effect can be subsumed in the area of human relations, there is little hope of a rational explanation of the vexing problems of the social order. We have just shown that the cross-sectional experimental design, because it is limited to a controlled comparison of two groups at a given time, fails to disclose cause-and-effect relations, although it may be suggestive of hypotheses for study by more elaborate methods. Does the projected experimental design offer a more hopeful promise of discovery of social cause and effect? Two published studies will now be analyzed in an effort to answer this question.

The first study was an attempt to measure the effects of a public low-cost housing project upon the social adjustment of slum families in Minneapolis from 1939 to 1940. One year is admittedly too short an interval for any real test, but practical considerations set this time limit, and so we are obliged to make the best of it.

This study began in the spring of 1939 when 108 former slum families having low incomes had taken up residence in Sumner Field Homes, a PWA housing project planned in 1935. The control group consisted of 131 other families residing in the same slum dwelling during the period. Although these 131 families were initially so much like those eligible and admitted to residence in the project as to be borderline or deferred cases who might be admitted later, an attempt was made to make the experimental group of residents and the control group of slum dwellers still more alike by matching on ten control factors: race or cultural class of husband, of wife; occupational class of husband, of wife; employment status of husband, of wife; number of persons in the family; income of the family; and years of formal education of wife. As in the studies previously reported, many cases were lost by inability to match. In all, 59 cases dropped out for this reason — 47 from the experimental group and 12 from the control group. Because of the lapse of time between initial and terminal measurements, various events intruded and 50 more cases dropped out for these reasons — 12 from the experimental group, and 38 from the control group. Forty-eight more cases were lost before the initial interviews were completed, owing to mobility, refusals, and other reasons, of which 5 were from the experimental group and 43 from the control. Thus the final matched groups (frequency distributions equated) consisted of 82 persons, 44 in the experimental group and 38 in the control group.

This test of low-rent public housing as a means to achieve the end of improved adjustment of slum families, or as a measure of a program of social reform as a cause, to produce improved adjustment as the effect, as the case may be regarded, relied upon changes in measured social adjustment before (1939) and after (1940) the program had operated for one year, as evidence of proof. The measures of social adjustment used were the same as those applied in the WPA-relief study described above. Since no changes in measured morale or in general adjustment were found statistically significant in a comparison of average scores of each group before and after, and also because each family had resided in the *same* dwelling unit for the period, there were in fact thus added three additional controls to the ten noted above, making in all, control on thirteen factors.

When, however, attention was directed to the changes that occurred in social activities (social participation scores), in the percentage use-crowded, and in the condition of the living room of each home (measured by the Chapin social status scale), it was found that a pattern of response consisting of these three factors in combination showed a difference between change in the experimental group and change in the control group that was of high statistical significance. Whereas the pattern of change on these three factors in the control group was not statistically significant (multiple critical ratio, 1.82), the corresponding change for the experimental group was highly significant (multiple critical ratio, 6.01); and the difference between the changes of the two groups on this measure was also highly significant (multiple critical ratio, 4.97). Such high critical ratios as these are so unlikely to occur in chance that a cause-and-effect relation may be inferred. In a certain sense this is a gratuitous conclusion because the public-housing program was intended to interfere with chance and to create for the project residents improved housing, so that it might be more surprising if it did not effect improved adjustment. This desired effect cannot be established by mere wishful thinking, however, but only by the evidence of measurements on scales that had been standardized to measure adjustment prior to the existence of the change they were used to test. Furthermore, although science often merely confirms the results of practices based on experience, it is by no means certain that a scientific test will not disprove the effectiveness of popular practices; hence the justification for the present study.

The real question that faces us in making inferences from the facts obtained by this experimental design is: Did housing per se cause these changes in pattern of response? Only a positive answer to this question, phrased in terms of a low probability of chance as an explanation, would prove the effectiveness of the public-housing program in this example, and then only if all unknown factors had been controlled. Although thirteen factors were controlled in rough degree, the remaining known but unmeasured factors (health, for example), and an undetermined number of unknown factors, were not controlled. Thus the results of this test by experimental design offer no final conclusion. Furthermore, since the groups compared were nonrandom samples, no reliance upon probability tests is permissible as a basis of generalization to any larger universe of similar "experiments" by public-housing authorities.

Where does this leave us? On the negative side we may offer the opinion that the results are sufficiently suggestive to urge repetition of this type of study on similar cases using like methods of research in the hope that replication will yield corroboration of the results. For only by replication in numerous similar studies may we escape from the dilemma of whether the obtained significant differences were due to the nonrandomness of the samples, or to the fact that they were drawn from different universes (i.e., universes that were made different by virtue of the public-housing program, the objective that was to be tested by the experimental design). Should the same results be found on many trials, then generalization from even nonrandom samples to a universe might be valid and justified. On the positive side we may say that the differences found were of an absolute magnitude which would be regarded as highly significant if they were found between two random samples.

Of the five principles enumerated as essential to study by experimental designs, three have been illustrated: social measurements by use of psychometric or sociometric scales; control by matching on measurements rather than by physical manipulation (the conventional and mistaken idea about control of variable factors); and qualified application of the principle of probability. But the housing study illustrates also the advantages to the research student that follow from the use of a null hypothesis in sociological research wherein the purpose is to test the results of a social reform program.

The conventional working hypothesis is a positive assertion: "Public housing improves the social adjustment of individuals and families living in a slum." There are at least two difficulties to be overcome in efforts to test such a hypothesis: first, the statement uses the normative term "improves," which implies the question "What is improvement?" Whose standards of what is improvement are to be taken? Shall we rely on the judgment of the housing manager, or on the opinions of those who promoted the project, or on the critics of all public housing? Obviously, any such definitions are open to subjective considerations which stem from different desires. This problem is simplified when standardized sociometric scales are used, since there was incorporated into the initial construction and testing of such scales elements of objectivity not present in individual opinions. Moreover, the norms of such scales were discovered in previous studies, so that the application of these scales in any present study is not affected by any desire to vindicate or to disprove the program being investigated. A second difficulty is more serious; it consists in the fact that "improvement" is an open-ended concept. How much change in the desired direction is improvement? When the positive hypothesis is replaced by a null hypothesis, this difficulty is avoided.

Three null hypotheses susceptible of proof or disproof by facts may be set up as follows:

1. When measures of adjustment are made upon an experimental group which receives a social program and an experimental group denied this program during an interval, and the two groups are matched on a number of factors, there are no changes in measured adjustment during the interval. Since the facts obtained in the housing study show the existence of changes, this null hypothesis is proved false.
2. If changes in measured adjustment are found in these groups, the changes are not statistically significant. Again this null hypothesis is proved false by the results found.
3. Although changes may be found, and these changes are statistically significant, the difference between changes of the two groups is not statistically significant. This null hypothesis is also proved false by the factual evidence.

It is evident that it is a much simpler task to prove that differences do exist, that these differences are statistically significant, and that the difference in changes is statistically significant as departures from zero than it is to prove that the changes are in the nature of improvement; and this is particularly the case in studies of problems of human relations, wherein bias is hard to avoid and the subject matter of study is emotionally disturbing to the observer because it involves his personal value systems.

A second study using the projected experimental design to test the effectiveness of a social program of differential treatment is that reported by Harry Shulman in New York City. This is a study of the effects of treatment to prevent juvenile delinquency by a controlled-activity program. The program consisted of workshop and game-room activities, classes in creative art, woodwork, leather, and metalworking, which met three sessions a week for two hours a session over a period of three successive school semesters. Groups of 50 problem boys and 80 normals were mingled naturally in these activities. The problem boys included chronic truants, incorrigibles, serious personality problem cases, and some charged with arson and theft. The normals were nonproblem cases obtained by serial selection from class-roll books of children who had never dropped below a B grade on their studies. The experimental group to receive the program consisted of 65 boys, including 25 of the problem cases and 40 normals. The control group was similarly constituted but denied the program. At the beginning there were 310 boys, 155 in each group, who were ten and one-half to fourteen and one-half years of age and in Grades 4-A to 8-A from four public schools in socially substandard areas of New York City.

The measure of community adjustment used consisted of 13 of the 66 Baker-Traphagen items which measured behavior status. Comparison of the results for the problem boys of the experimental group with the problem boys of the control showed that 72 percent of the problem boys in the experimental group which received the program improved, and only 33 percent of the problem boys in the control group gained. Meanwhile 28 percent of the former had lost, and 66 percent of the latter. In tests before and after in the classroom situation, all differences among the mild-to-medium conduct-disorder cases were statistically significant on scores of the Haggerty-Wickman-Olson behavior rating scale for the two problem children groups. Since these favorable results might have accrued from differential changes in home environment during the experimental period, a case study was made of factors of family disorganization (broken home, marital disharmony, public assistance, economic maladjustment, children's illness, mental deficiency and disease, unethical or antisocial example, etc.), of defective social relationships (between parents, parent-child, and community), and also of improper discipline. The results of this analysis showed no appreciable differences in changes for the problem children of the two contrasting groups. Thus the intrusion of environmental factors of the surrounding community had not operated to confuse the relationship between the treatment program as a cause and the diminution of behavior problems as an effect.

Although the two studies in projected experimental design just described illustrate some advance toward the scientific goal of discovery of social cause-and-effect relationships, each study stands by itself as a closed system, and no scientific generalization may be made from either to the larger universe of housing or juvenile delinquency. Again, repetition by similar studies on like subjects, using the same methods of research, is the only avenue of approach to a reliable basis of generalization.

EX POST FACTO EXPERIMENTAL DESIGN

For many years students of human relations have sought a valid method to discover cause-and-effect relations which it is believed may be hidden in the records of past social events. The ex post facto experimental design was developed as one attempt to clarify this methodological problem.

A study that illustrates the use of this ex post facto method was made by Helen Christiansen under my direction in 1935–38. The positive hypothesis to be tested was the longer the period of high-school education before leaving school, the better the subsequent economic adjustment in the community. Here the formal high-school course of instruction is taken as the program variable, or the causal factor, and measured economic adjustment is taken as the effect variable. To test this hypothesis the records of 2,127 high-school students who left school nine years earlier (1926) were obtained and analyzed. In that year 1,130 had graduated from the 4-year course in all high schools of St. Paul, Minnesota, and 997 had dropped out of school, having been in 1926 at the end of their first, second, or third year of study. The graduates were taken as the experimental group and the drop-outs as the control group. The measure of economic adjustment in the community situation chosen as the dependent variable was the percentage of shifts on jobs from 1926 to 1935 which involved increase in salary, no change in salary, and decrease in salary. This is admittedly a crude measure, but the data could be obtained by interviews of all persons of the original 2,127 who could still be located in 1935.

Considering the relatively long experimental period of nine years, substantial losses of cases were to be expected. As a matter of fact, 933 individuals were lost for analysis, 459 of the graduates and 474 of the drop-outs, for reasons of death, moving away, not located, or incomplete records. After matching on six control factors, age, sex, father's occupation, parental nativity, neighborhood of residence and average high-school marks (no I.Q. data were available in 1926), the two groups were reduced to 145 individuals each.

Analysis of economic adjustment to the community in 1935 showed a regular decline in percentage with decrease in salary or no change in salary, with each additional year of high-school education for drop-outs of 1, 2, and 3 years of study, and a regular increase in percentage with salary increases. The 4-year graduates attained the highest percentage with salary increase for 1926–35 of any group, and their percentages of cases with decline in salary or no change were approximately the same as those of the 3-year drop-outs. When the matching technique was made more precise — that is, by identical individual matching, instead of equating frequency distributions on each control factor — the two groups were reduced to 23 cases each. The trend in percentages on the salary criterion became even more pronounced, and the advantage of the graduates over the drop-outs was much greater. All in all, the positive hypothesis seems to have been established for this study, provided the results can be explained as not due to health factors uncontrolled, the factor of persistence in school work, the existence in the group of 933 lost from study of trends contrary to those found in the groups that were analyzed, or unknown factors. Again no decisive proof has been achieved; only the probability of a cause-and-effect relation between length of school attendance and subsequent economic adjustment in the community.

But this matter of probability deserves further exploration. To test the statistical significance of the percentage differences found between the experimental and control groups, two random samples of 23 cases each were chosen from the larger experimental and control groups, but the individuals in these random samples were not matched (as were the individuals in the 23-case terminal experimental and control groups which showed the largest differentials). Analysis of the random samples showed indicia of differences in community adjustment occurring by chance as 1 in 14, as compared with 1 in 200 for the 23-case matched samples. Since the original 2,127 cases constituted the universe of all who left high school in 1926, and the remaining 1,194 cases composed the remainder after losses of 933 cases, both the random samples and the experimental groups were from a subuniverse, so that comparison of real random samples with nonrandom groups introduces in this experiment a more adequate basis for the use of probability tests than was the case in any of the other studies described in this article.

In summary, it may be said that the differentials in favor of the graduates seem too large to be explained as mere chance fluctuations, and of absolute magnitudes that cast some doubt upon the validity of the four alternative explanations, which would set up the claim that it was not the length of high-school education that caused better economic adjustment in the community of graduates. The comparison with the random samples yields results also consistent with the foregoing inference.

But, again, we must caution against generalization to all high-school programs of all areas of the United States. Perhaps the place and time studied were unique. On the other hand, it may be pointed out that the 1926–35 period included the depth of the great depression of the 1930s, so that the hypothesis was substantiated for an interval of sharp testing by unemployment, and hence that our conclusions have a safety factor that makes them conservative.

A variation in the ex post facto design was made in a study of public housing and juvenile delinquency in New Haven by Naomi Barer from records of 1944 on 317 families traced back to 1924. She made a self-comparison of a group of 649 children seven to seventeen years of age in these families, for the period 1940–44 to the period 1924–40, when the same families and their children lived elsewhere. From 1924 to 1940 the rate of juvenile delinquency per 100 children per year was 3.18; when the same subjects were residents of the housing project the rate had declined to 1.64. This is a statistically significant decline. During the years 1940–41 there was an increase of 9.1 percent in total juvenile delinquency in the city of New Haven over that of the period 1927–40, so that no general decline in juvenile delinquency occurred in the community at large, which, if it had happened, might explain the decline of the experimental group of children in the housing project. No generalization is justified from this study alone about housing and juvenile delinquency at large. Only corroboration from repetition of the experiment will furnish proof of a hypothesis that good housing operates to reduce juvenile delinquency.

Two types of critics deplore the kind of studies herein described. There are the "practical" reformers who have expressed the opinion that this kind of detailed analysis is superfluous since it is mere common sense to expect to find improvement following upon well-matured plans for social betterment. But are desire and wishful thinking the sort of support upon which to base and to justify expensive and elaborate social programs? Then there are sincere critics who express the judgment that the time and expense of detailed study by experimental designs might better have been applied to the investigation of problems wherein the expectation of significant results had a firmer basis in technical and precise research methods. No adequate answer can be made to this criticism. The reader will have to decide for himself whether exploration by these methods of experimental study, admittedly crude and lacking in precision, is worth the time and effort put forth. In any event, I have found these experimental designs interesting, and sometimes exciting, ventures. They are offered for what they may be worth, and their limitations have been stated and reiterated throughout his article.

Three closing comments may be made. First, objective evidence has been offered to show that experimental designs may be applied to the measurement of problems of human relations with some expectation of a partial clarification of social cause and effect in society. Second, the chief obstacle to the experimental method in the study of problems of human relations is removed, since it stemmed from a false analogy between "social experiments" that shove people around and laboratory experimentation that manipulates physical matter, whereas the fundamental principle involved is observation of social relations under conditions of control, which conditions are attained by matching on social measurements, and do not require interference with personal freedoms. Third, the methods of experimental design offer the promise of an objective procedure for evaluating the effects of some types of social reform programs. Such programs consist of the approved means chosen to attain some desired or valued end. This being the case, it seems possible that further extension of the methods described herein will lead to an experimental test of values, phenomena hitherto circumscribed by desire and wishful thinking and suffused with emotional attitudes.

If the first expectation is realized, we may have in it the beginnings of a rational basis for the amelioration and control of some of the problems of human relations. If the third is realized, we shall have a rational substitute for mere subjective opinions and sanctimonious or self-righteous judgments about what may be done by social action to achieve collective desires. Furthermore, through the replication of experimental design studies, which attempt to measure the effectiveness of specific means-ends schema planned to attain specific goals, it may be possible to develop a systematic mosaic of nonrandom samples that will possess a degree of representativeness to compensate for lack of randomization, and thus to supply a basic representativeness upon which reliable scientific generalization may rest. Finally, if the foregoing development takes place, an approach will have been made to the solution of the most difficult methodological problem of all, to describe objectively the tortuous chain of social cause and effect that now lies hidden in the unplanned social consequences that seem to flow from the combinations of innumerable and independently planned social actions within a democratic society.

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The Science of Human Learning, Society, Culture, and Personality

GEORGE PETER MURDOCK

It has often been said that modern man's technological progress has developed far in advance of his understanding and control of human relations. Various notions have been proposed as to why this is so, and what might be done about it. One example of "what might be done about it" is described in this selection — the integration of several disciplines into a unified science which would bear upon social problems. Murdock describes the theoretical basis for such an approach in socially transmitted, learned behavior patterns. He presents the thesis that the basis of human personality lies in the various ways we resolve conflicts between inherited impulses and social demands. Although the consolidation of sciences described by Murdock is not as broad as that implied by the term behavioral sciences as used in this book, it would have some of the same advantages that are described.

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The past decade has witnessed a revolutionary development in the psychological and social sciences. A number of disciplines that had previously pursued independent courses in the analysis of particular facets of man's individual and social behavior have been discovered to dovetail into one another so neatly that they are well on the road to being fused into a single integrated science. The first major steps in achieving this integration were made at the Institute of Human Relations at Yale University, but the movement has spread to other institutions and is being pressed forward with especial vigor by the new Department of Social Relations at Harvard University.

This development has been widely misunderstood as a mere pooling of separate scientific skills and techniques on cooperative research programs. The significant fact, however, is that the integration has taken place at the level of theory. At least four previously distinct systems of theory have been found to interdigitate so that each supports the others and is in turn illuminated by them. These four are the theory of learning and behavior developed by behavioristic psychologists, the theory of social relationships and social structure developed by sociologists and social anthropologists, the theory of culture and cultural change developed by anthropologists with significant assistance from sociologists, and the theory of personality and its formation developed by psychoanalysts and psychiatrists.

There is as yet no general agreement as to an appropriate name for the emerging unified science. Such terms as "human relations" and "social relations" slight the psychological components and, to some, suggest application rather than theory. The "science of human behavior" carries too strong a connotation of behaviorism and too weak an implication of important social and cultural factors. The general term "social science" seems to exclude psychology. In default of an apter expression, we shall, with tongue in cheek, use "lesocupethy" — coined from LEarning, SOciety, CUlture, and PErsonality THeorY. Perhaps it will irritate some reader into proposing a more satisfactory name.

I

The position of "lesocupethy" in the hierarchy of the sciences poses no difficulties. It is rooted in biology as the latter is rooted in chemistry. But as biology is differentiated from chemistry by complications introduced by living matter, so is "lesocupethy" distinguished from biology by complications resulting from the interaction of learning and society.

In themselves, learning and society represent two of a considerable number of major types of adjustment which have been independently developed several times in the course of organic evolution. Other examples include parasitism, symbiosis (e.g., plants which depend for pollination upon bees, which in turn depend upon the nectar of the plants for food), and aerial locomotion (independently achieved by insects, pterodactyls, birds, and bats).

The most basic type of behavior mechanism with which nature has equipped its living species is instinct. The organism is provided by heredity with a structural organization whereby it automatically responds to stimuli by specific forms of behavior which through natural selection have become established as adaptive in the life conditions typically encountered. Being essentially rigid, however, instincts cannot help the organism if conditions diverge from the typical. To meet this situation and prevent wholesale extinction of species under fluctuating conditions, organic evolution has developed inherited mechanisms of learning in all but the simplest species. These supplement instincts by enabling the individual organism to modify its behavior adaptively within a greater or lesser range of varying conditions. A notably flexible mechanism of learning is hereditary in all mammalian species. Experimental psychologists who have made intensive studies of animal learning agree that the basic mechanism in man differs in no significant respect from that in other higher mammals. The fundamental principles of acquired behavior are thus mammalian rather than specifically human, and can be illuminated by experiments with rats and dogs just as experiments with fruit flies have advanced the knowledge of human genetics.

Social life is another major type of adaptation which organic evolution has repeatedly produced. Gregarious species are exceedingly numerous, but the most startling superficial resemblances to man are found among the social insects — bees, wasps, ants, termites. In most instances natural selection has created social aggregations by equipping a species with hereditary mechanisms which have the effect of attracting individuals instinctively to one another. Sex is one example. Another is the sweet juices exuded by certain social insects for the delectation of their fellows. Brought into association in some such way, the members of a society enjoy advantages not available to isolated individuals — for example, mutual protection, insurance, enhanced power, and the benefits of a division of labor.

Although neither learning nor society is peculiar to man, in conjunction they have produced something unique in nature — a new level of complexity in natural phenomena which demands for its understanding a distinctive body of scientific theory. The inherited mechanism of learning and the hereditary bases of social life will ultimately yield their secrets to biological science, but the products of their interaction will require the special sciences that compose "lesocupethy," at least until the millennium when all biology has been reduced to chemistry and all chemistry to physics.

Except in man, what the individual of any species learns in his lifetime dies with him. Every individual in every generation starts from scratch. All or most of what he learns he acquires for himself. He derives little or no benefit from the experience of others, even if his species is one of those characterized by social life. In man, however, most of the behavior acquired by any individual, in whatever part of the world or period of history he may live, has previously been learned and found adaptive by other and older members of his own society, and he in turn transmits this behavior, together with any adaptive modifications acquired through his own life experience, to other and younger members of his social group. The interaction of learning and society thus produces in every human group a body of socially transmitted adaptive behavior which appears super-individual because it is shared, because it is perpetuated beyond the individual life span, and because in quantity and quality it so vastly exceeds the capacity of any single person to achieve by his own unaided effort. The term "culture" is applied to such systems of acquired and transmitted behavior. Since cultures change with the varying and cumulative experience of individuals in social groups, it becomes possible to say of man, as of no other species with the hereditary capacity to learn, that societies as well as individuals learn. Social learning is synonymous with cultural evolution.

In social species other than man, the forms of social organization are primarily determined by the biologically inherited mechanisms which produce association. They are therefore the same in all societies of the species, except for minor modifications dependent upon ecological or demographic factors. Among fur seals, for example, one does not find some groups with matriarchal and polyandrous families, nor among honeybees some hives with kings and male workers. In man, however, extreme differences in social organization are common, even in tribes of the same subrace, language, and geographical area. Among the Siouan tribes of the Western Plains, for example, the Omaha are patrilineal and the Mandan matrilineal, and among the Malayan tribes of Sumatra the Batak are patrilineal and the Minangkabau matrilineal. The conclusion is therefore inescapable that in man — alone among the social animals — society itself is largely learned, i.e., is the product of cultural rather than of biological evolution. To be sure, biologically conditioned social bonds are not wholly absent. Thus lactation helps to link mother and child, and sex to bind husband and wife, in the organization of the human family. No biological or innate basis is discernible, however, for the overwhelming proportion of the social ties which produce the complex organizational structures characteristic of human groups.

Since human society is never a spontaneous expression of biological potentialities but must always be learned as a part of culture, it follows that man must be molded to his society much as a colt is broken to harness. He must, in short, be "socialized." In all societies this is largely accomplished during infancy and childhood, when the culture of the group is implanted by inculcation, and the unsocial or antisocial impulses with which the child is born are disciplined and redirected to fit him for the social roles he must fill as an adult. Conflicts are thus inevitably set up in the developing child between his biologically inherited impulses and the demands of his society as these are imposed upon him by his parents and later by others. The manner in which these conflicts are resolved by the individual, reflecting the concrete circumstances under which the social disciplines are impressed upon him, largely determines his "personality."

II

It should by now be abundantly clear that learning, society, culture, and personality are far indeed from being separable entities, even though until recently they have mainly been studied in isolation by psychology, sociology, anthropology, and psychoanalysis, respectively. Their interrelationships are so intimate that leaders in all four fields are coming more and more to recognize that they form the subject matter of a single integrated science. So significant are the interrelationships that they deserve somewhat fuller exposition.

Since society, culture, and personality are all learned, students of any of these phenomena must constantly bear in mind the fundamental principles of learning as these have been worked out by such behavioristic psychologists as Hull. Unless they do so, their conclusions will suffer in clarity if not in validity.

Knowledge of the structure of society is equally fundamental to the students of learning, culture, and personality. It forms an essential part of all normal situations in which human beings learn. Unless he reckons with it, the behavioristic psychologist can never explain adult human learning, however accurately he may account for the acquisition of habits by rats and other nonsocial animals. Culture only exists in, and is borne by, organized human groups and the anthropologist who ignores the latter can tell us little of significance about the former. Since personality is largely the product of group pressures, the psychoanalyst should reckon with all important aspects of a society's structure. In our own society, for example, if he deals only with the family situation, and overlooks such significant structures as those of status and prestige, his interpretations will fall far short of completeness.

Culture is deeply relevant to the study of learning, society, and personality. Most of what any human individual learns is already part of the culture of his group, and the cultural habits that he already possesses in large measure predetermine his behavior in any new learning situation. The psychologist can ignore culture when he studies the behavior of rats or dogs, but if he does so when his subject is man, his explanations may be wide of the mark. Since social interaction always takes place within a framework of social structure, which is regularly a part of culture, sociological generalizations made without reference to culture are likely to be meaningless. Culture is crucial to the analysis of personality, not only because traits of the latter are often socially shared but also because the disciplines through the imposition of which personality is formed are largely prescribed by the culture.

Personality is no less significant than is culture for an understanding of human learning, since the reaction of any individual in a learning situation is likely to reflect significantly his resolution of the conflicts arising during his socialization and the unconscious anxieties and hostilities generated thereby. Society, too, reflects personality factors. Thus, as the sociologist Sumner showed long ago, human societies are characterized by "antagonistic cooperation" because of the conflict between individual impulse and social pressures, and they exhibit the phenomenon of "ethnocentrism" because the hostilities generated but suppressed by in-group disciplines are displaced toward other groups in such forms as race prejudice, religious intolerance, and national rivalries. Personality also affects culture. It appears, for example, to be a significant factor in the development of what is called "national character." Moreover, as Kardiner and Linton have shown, certain aspects of culture, such as religious beliefs, tend to be reflections or projections of attitudes commonly engendered during the socialization process.

During the early attempts at the Institute of Human Relations, in 1935–42, to assemble the theories of learning, society, culture, and personality into a single integrated discipline, two very important discoveries were made. The first was that the four theoretical systems, although developed in relative isolation, fitted together almost as well as the adjacent pieces of a jigsaw puzzle. The gaps and inconsistencies were unexpectedly few. Other systems of theory fitted much less well — some because of dubious validity, others because of their more limited scope or more pragmatic character. Economic theory, for example, appeared to be related primarily to the conditions prevailing in a restricted group of complex societies during a limited period of history, and thus to be culture-bound rather than universal. It had, for this reason, afforded little help to anthropologists in understanding the economic behavior of primitive peoples.

The second major discovery was that each of the four systems shed new light on the others and often converted ambiguity into clarity. Thus, learning theory demonstrated that personality is really learned, despite Freud's persistent invocation of "instinct," and it corroborated Malinowski in his insistence that culture is always functional and does not persist through sheer inertia. Personality theory showed that the concept of "drive" as well as of "stimulus" is necessary in order to comprehend the motivation of learning, and it illuminated the view of Sumner that the elements of culture are emotionally charged rather than neutral or devoid of affect. The theory of social structure revealed that Freudian psychology rests on sociocultural as well as on biological or physiological assumptions, being concerned with the products of learning under conditions presented by family organization and the imposition of social sanctions. Culture theory demonstrated that psychological principles are never competent to explain any social phenomenon unless account is taken, not only of behavior mechanisms, but also of the historically determined conditions under which these mechanisms operate, particularly the so-called cultural base and the prevailing structure of social relationships.

The manner in which the four originally independent systems of theory have been found to dovetail gives confidence in the essential validity of each, and the new insights that each has brought to the others confirm the impression of their essential unity. Recent work by anthropologists like Gillin and Hallowell, sociologists like Merton and Parsons, psychologists like Mowrer and Sears, and numerous others reveals that the integrated discipline which we have dubbed "lesocupethy" is approaching maturity. It is perhaps best exemplified to date in the volume *Social Learning and Imitation*, by Miller and Dollard. I have myself recently shown, in *Social Structure*, that there are some problems of social science — e.g., the incidence of incest taboos — that are capable of solution only when findings from all four of the constituent disciplines are applied conjointly.

The juxtaposition of the several behavioral sciences has also revealed areas in which intensive research is urgently needed. One such is related to the fact that much of human behavior is ideational, depending upon the use of linguistic and other symbols. What the Gestalt psychologists have called "insight," and others "intelligence," is known to be of enormous importance in learning. When exhibited by human beings this is believed to involve a transfer of trial-and-error behavior from the motor organs to an ideational process utilizing implicit linguistic symbols, the individual resorting to a motor response only after he has "thought out" a promising solution to the problem facing him. That this symbolic process can use other than verbal tools is demonstrated by the fact that the anthropoid apes as well as man exhibit insight or intelligence. At present it can only be assumed that the same principles of learning are involved in ideational as in motor behavior. This conclusion must, however, be established or revised by experimental methods, for until this is done the exact bearing of learning theory upon personality and culture, in both of which symbolic behavior plays a highly significant role, will remain uncertain. In any such research the participation of experts in linguistics and semantics will be as essential as that of psychologists.

III

The disciplines that compose "lesocupethy" have in common the fact that they all deal exclusively with acquired behavior. It is readily admitted that biological factors bear directly upon human behavior in diverse ways. Learning is obviously affected by the physiological condition of the individual. Society, as already noted, has biological underpinnings in such phenomena as sex and lactation. Culture is possibly influenced in some small measure by racial heredity, and, as Gillin has pointed out, definite limits are set to its variability by man's innate endowment. Constitutional factors certainly play a prominent role in psychotic aberrations and very likely also in normal personality. The interpretation of all these and other comparable influences, however, is a task of the special biological sciences. "Lesocupethy" is concerned only with what is left when these are factored out. That this is a major assignment there can no longer be any doubt.

Incidentally, there is not yet sufficient recognition of the fact that vastly more is scientifically known about the acquired than about the innate factors in man's social behavior. Precise knowledge of the latter must in many cases await the full development of human genetics, which in the very nature of the case cannot be achieved until several generations have elapsed. By that time the integrated science of acquired behavior should have developed a hundredfold.

In all fields of science there are segments of verified knowledge which have not yet been integrated with the basic theoretical system of the discipline. In the social and psychological sciences there are comparable segments — most notably perhaps in sociology, economics, linguistics, and social psychology — which "lesocupethy" has not as yet assimilated. Thus far, however, there is in this field little evidence of major alternative theories, verified but unreconciled, concerning the same body of phenomena, comparable to the wave and corpuscular theories of light. Can it be that man's social behavior is actually less complex, not more complex, than the subject matter of physical science? And is it not perhaps possible that we may have more of the essential answers to the basic scientific problems even earlier in the former field than in the latter?

The union of disciplines which we have called "lesocupethy" is a pure science. Its objective is the maximal theoretical understanding of the peculiar ways of men. It does not directly seek the solution of any practical problem. Naturally it has much in common with such applied sciences as psychotherapy, social work, education, industrial relations, and colonial administration, just as the physical and biological sciences are applied in war, engineering, industry, agriculture, and medicine. Admittedly the applied sciences continually add substantial increments of knowledge to the pure sciences upon which they depend. Nevertheless, history has shown, and both industry and government now recognize, that the support of research in pure science frequently yields richer dividends through the application of newly discovered basic principles than are obtainable by a direct attack upon specific practical objectives. It is therefore not inconceivable that the cultivation of "lesocupethy" as a pure science may lead more quickly to a solution of international conflict, economic insecurity, industrial strife, family disorganization, and individual mental disorders than research oriented directly toward the solution of these pressing problems.

But whether or not such high aims are realized, the emergent integration of the basic theoretical systems of the social and psychological sciences undoubtedly represents one of the great turning points in the history of science. In significance it may prove the equal of the contributions of Darwin and Mendel in biology. In kind, however, it perhaps resembles more closely the extraordinary integrating achievement of Einstein in the field of physical science.

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Our Changing Conception of Human Nature

M. F. ASHLEY MONTAGU

The author of this selection presents the environmentalist's point of view about the sources of human nature. "Being human must be learned," he says, and in his essay he develops the theme that above everything else, man is malleable, adaptable. Environment begins to shape personality not at birth but at fertilization. The foetal milieu, Ashley Montagu holds, has greatly influenced the expression of hereditary potentialities by the time of birth. Thereafter, acquired experience and the impress of the prevailing cultural pattern determine human nature. As an example of human characteristics, the author discusses aggression and hostility in the environmentally determined frame of reference. This article makes an interesting contrast with Bertalanffy's biological view in selection 44.

Dr. Ashley Montagu is an author of several books on physical and social anthropology and was chairman of Rutgers' Department of Anthropology for several years. The selection below was published in the UNESCO journal *Impact of Science on Society*, Winter, 1952 (pp. 219–232). Distributed in the United States through UNESCO Publications Center, 475 Fifth Ave., New York 17, N.Y. (a division of the National Agency for International Publications, Inc.). It is reprinted by permission of the publisher.

Theories on human nature have been as numerous as the proverbial leaves of Vallombrosa, but it was not until the beginning of the twentieth century that human nature became a subject of serious scientific study. This study has revealed a multiplicity of facts which neither the theologians nor the philosophers so much as surmised. The facts set out in this article, and their discussion, should serve as a challenge to social thinkers and the leaders of public opinion.

WHAT IS HUMAN NATURE?

The answer to this question is, of course, the purpose of this paper. Obviously "human nature" can mean several different but mutually reconcilable things at one and the same time, so that until we have explored these different meanings and reconciled them, it will not be possible to make a brief, valid and readily understandable statement as to the nature of human nature. However, it is possible to say several significant things about it at once.

First, then, it should be said that no organism of the species so prematurely named *Homo sapiens* is born with human nature. What human beings are born with is merely a complex of potentialities. Being human is not a status *with* which but *to* which one is born. Being human must be learned. This is an important distinction, for the age-old belief in the innate nature of human nature has been responsible for much personal, social, and political misunderstanding, and for an untold amount of human suffering.

What are the specific qualities or characteristics, and what is the peculiar nature, of man that distinguish him from all other creatures? On the basis of his obvious physical characteristics man is described as a mammal of the order Primates, genus *Homo*, and species *sapiens*. But what of his psychological classification? While every creature that is classified physically as man is thereby called *Homo sapiens*, no such creature is really *human* until it exhibits the conduct characteristic of a human being. If it is true that one has to learn the kind of conduct that is uniquely human, then any organism which fails to learn that conduct cannot be human. In a sense this is a sound argument, and a closer examination of this argument will serve to throw much needed light upon the meaning of human nature.

The fact is that man is human by virtue of both his physical and his mental traits. In the course of his evolution the two appear to have gone hand in hand. One can no more deny the status of being human to a newborn baby because it cannot talk, than because it cannot walk erect. The wonderful thing about a baby is its promise, not its performance — a promise to perform under certain auspices. A juvenile ape can do a great deal more than can a juvenile human (*1*), but the promise of the child far exceeds that of the brightest of apes.

Now, what is this promise? The answer is: a remarkable capacity for learning to use complex symbols and symbol relationships (*2*), a symbol being a meaning or value conferred by those who use it upon any thing. A sign, on the other hand, belongs to the physical world, it is a physical thing which indicates some other thing or event. A symbol belongs to the human world of meaning. Now, it is generally agreed that newborn babies are incapable of symbol usage; it is an ability which they have to learn; if they are not taught it they do not learn it.

We can thus say that human nature means the uniquely human set of *potentialities* for being human with which the organism *Homo sapiens* is born. *Potentialities* must be underscored, for what is generally erroneously assumed is that human beings are born with certain definite traits and characteristics which only need time if they are to develop, whereas the researches of the last 30 years have increasingly shown that the traits and characteristics of the organism will to a very large extent be determined by the kind of cultural stimulation which those potentialities receive.

What most persons have taken to be human nature, is actually the *acquired* behaviour of the person; this may and usually does become a second nature, and this, too, could be called human nature, since it is a function of man's nature in interaction with his environment, but it must not be confused with man's *inborn* nature — and this is exactly where the confusion is usually made. No doubt, since one always learns in a particular human environment, one's potentialities will develop according to the pattern of conditions to which they are exposed. Hence, human nature may express itself or rather be made to express itself, in many different forms. But the differences in these forms are not, according to modern evidence, determined by innate factors but by environmental ones.

Man is born not with the ability to speak any language, but with a capacity or potentiality for speech, and this potentiality will never develop in the absence of the proper stimuli. These stimuli will usually assume a form determined by a particular environment, so that what the organism learns to speak will be of purely social origin, just as the way in which he learns to eat will be socially determined. Now languages, knives and forks, and fingers, are all instruments for manipulating one's environment, but whereas fingers are natural, languages and knives and forks are artificial. Obviously it is no part of the primary or innate nature of man to create artifacts. Science knows of no natural drive in man to make knives and forks or to speak Italian; Australian aborigines neither use knives or forks nor do they speak Italian, not because they couldn't do so, but because they happen to be born into a cultural environment from which such instruments are absent and where their own language alone is spoken.

In short, how a person will behave, what he will do, think, or say, what language he will say it in, and what artifacts he will prize, will be determined not by his innate nature so much as by his acquired experience. And this gives us the answer we have been seeking: human nature consists of the unique potentialities for complex symbol usage with which the organism is born, potentialities which undergo development within the matrix of a stimulating cultural environment, the emergent result being a human being, made to measure, and tailored to the prevailing cultural pattern in which he has been conditioned. The process of learning the traditional cultural patterns is called *socialization*, and is essentially cultural in character. We may, then, call the cultural endowment of human potentialities *primary human nature*, and the socialized development of those potentialities *secondary human nature*. Human nature, therefore, consists of both primary and secondary elements, the innate *and* the acquired. Where most errors have been committed in the past has been in the identification of the latter with the former.

While the primary human nature of all men is fundamentally similar, the secondary human nature frequently differs owing to differences in the history of cultural experience (3). In short, human nature assumes secondary forms according to the pattern of the socialization process in which it has undergone development, and this pattern is determined by the cultural history of the group (4).

HUMAN NATURE BEGINS TO BE INFLUENCED AT FERTILIZATION

In the tradition of Western civilization it is the custom to reckon age as beginning from birth; other civilizations, notably the Chinese, reckon age as beginning from fertilization or conception. Accumulating recent researches indicate that this is scientifically a much sounder manner of reckoning age than our own. The tendency to think of the child being born as a sort of *tabula rasa*, without a previous history, and beginning life, as it were, for the first time at birth, is wrong. The teaching in our scientific institutions hitherto has been that the foetus *in utero* is so carefully protected, so thoroughly insulated from virtually all stimulations originating in the mother or the outside world, that it develops autochthonously according to its own inner resources and the nutriment which it receives through the placenta. It was and is still being widely taught that since there is no nervous connexion between mother and foetus, the mother's nervous states could not possibly influence the development of the foetus in any way.

With such a viewpoint concerning maternal-foetal relations it is not to be wondered at that the prenatal period was considered irrelevant for the study of human nature. And yet nearly a century and a half ago a poet and thinker, Samuel Taylor Coleridge (1772–1834), wrote: "Yes — the history of a man for the nine months preceding his birth, would, probably, be far more interesting, and contain events of greater moment, than all the three score and ten years that follow it" (5). It has taken science 150 years to come somewhere near supporting Coleridge's guess.

It is now a demonstrable fact that there is a very intimate connexion between the nervous system of both mother and foetus; this connexion is established through what is increasingly coming to be known as the neuro-humoral system. This system is composed of the interrelated nervous and endocrine systems acting through the fluid medium of the blood (and its oxygen and carbon-dioxide content) (6).

There is good evidence that an emotionally disturbed pregnant woman may communicate her emotional disturbance, at least in chemical form, to her foetus. The Fels Institute workers at Antioch College, Yellow Springs, Ohio, have found that emotional disturbances in the pregnant mother produce a marked increase in the activity of the foetus. They have also found that fatigue in the mother will produce hyperactivity in the foetus; and that under severe emotional stress, especially during the later months of pregnancy, such mothers generally have babies who become hyperactive, irritable, squirming, feeding problems. Such an infant, says Sontag, "is to all intents and purposes a neurotic infant when he is born — the result of an unsatisfactory foetal environment. In this instance he has not had to wait until childhood for a bad home situation or other cause to make him neurotic. It has been done for him before he has even seen the light of day" (7).

Not only this, there is evidence that the mother's emotional disturbances are reflected, through disturbances in nutrition, in the skeletal system of the foetus (8). It is, of course, not being suggested that the mother's emotional states as such are transmitted to the foetus — this is almost certainly not the case. What does apparently occur is that the mother's emotional disturbance manifests itself in impulses which, passing from cortex to thalamus and hypothalamus, proceed along the infundibulum to the pituitary gland. The latter then secretes various hormones directly into the blood stream which activates the glands of the rest of the body, and since most, if not all, of these hormones are of small enough molecular size, they will pass directly through the placenta into the foetus, and there act upon it.

It is now well established that the foetus is capable of responding to tactile stimuli, to vibrations, differences in pitch and tone, and to sound, to taste, and to various gases (9). In other words, it is clear that far from being thoroughly insulated from the outside world, the foetal organism is a great deal more sensitive to it than we ever suspected.

Even more important than these is Spelt's remarkable discovery that the human foetus, *in utero*, during the last two months of gestation can be conditioned to respond to a paired stimulation of a vibrotactile conditioned stimulus and a loud noise as unconditioned stimulus (*10*). This is the first successful experimental attempt to condition the human foetus *in utero*. Evidently, the foetus at 7 months gestation age already has a sufficiently highly developed nervous system to be able to perform the operations necessary for learning.

Greenacre thinks that the evidence indicates the possible existence of pre-anxiety reactions in foetal life without, necessarily, any psychic content (*11*). She suggests that traumatic stimuli such as sudden sounds, vibrations, umbilical cord entanglements, and the like, including the "trip through the birth canal," may produce a predisposition to anxiety which, combined or not with constitutional traumatizing birth experiences, might be an important factor in the severity of any neurosis.

Without dwelling any further upon these facts, it should be reasonably clear that by the time a foetus is born it is highly probable that the genetic structure of its potentialities for being human has already been more or less greatly influenced by the environment in which it has undergone development, and that hence, the primary human nature with which the organism *Homo sapiens* is born is not simply the genotypic potentialities as laid down at fertilization, but the more or less environmentally-modified expression of those potentialities.

Such facts and their understanding, it will be readily granted, are of the first importance for the improvement of human welfare. The care of the child should, of course, begin with conception, and the best way of caring for the developing human being is caring for the mother during and after her pregnancy.

HEREDITY AND ENVIRONMENT

Before proceeding further with the discussion, a few words must be said concerning the spurious dissociation between what is in fact only arbitrarily separable, namely, heredity and environment. Heredity is usually taken to mean the innate, i.e., the unadulterated biological inheritance of the organism as determined by the genes or hereditary particles in the chromosomes. This is usually referred to by geneticists as the *genotype*; the visible expression of the genotype is termed the *phenotype*. Now, the genotype always undergoes development within the complex medium of an environment, and the environment to a greater or lesser extent *always* influences the development of the phenotype. Hence, what the organism inherits is both the genotype and the environment which has formed it before birth. To disentangle what is due to genotype and what to environment, more especially where behavioural traits are concerned, is a task beset with unsolved difficulties. What is, however, clear is that behavioural traits are due to a combination of genotypic and environmental factors with, by and large, environmental factors playing a dominant role. This by no means excludes genotypic factors, but it does suggest, other things being equal, that insofar as behavioural traits in man are concerned, man's social heredity plays a more considerable role than does his physical heredity.

Since, then, the heredity of a person consists of the interactive effects of the innate potentialities for development within the environment, it follows that where we control environment we to some extent control heredity. This is an extremely important conclusion, for it tells us that the most effective way for human beings, for some time to come, to influence the expression of the genotype is through the environment. Heredity in the genotypic sense may determine what we can do, but environment determines what we do do (*12*).

CONSTITUTION

In view of the recrudescence of a constitutional school of human nature, which attempts to link man's behaviour to his physical traits (*13*), it is desirable here to say a few words concerning the conclusions reached by scientists with respect to the nature of constitution. Constitution may be defined as the sum total of the structural, functional, and psychological characters of the organism. It may be regarded as the integral of genetic potentialities influenced in varying degrees by internal and external environmental factors. Constitution is more properly regarded as a process than as an unchanging entity. It is not a biological entity, a structure predestined by its genotype to function in a predetermined manner. The manner in which all genotypes function is determined by the interaction of the genotype with its environment.

All the relevant researches indicate that every genotype is a unique physico-chemical system comprising particular kinds of potentialities having definite limits. These limits vary from individual to individual, so that were the genotype to be exposed to identical environment conditions, its interactive expression would nevertheless continue to vary from individual to individual. In point of fact the environmental conditions are never the same for two individuals — a fact which renders it necessary for us to remember that heredity is not merely constituted by the genotype, but by the genotype as modified by the environment in which it has developed. The fact cannot be too often reiterated that what the organism inherits is a genotype *and* an environment: that heredity is the dynamic integral of both, the resultant of the dynamic interaction between the two.

Finally, it has become quite clear that genes, the heredity particles carried in the chromosomes, do not determine either character or traits; what they determine are the responses of the developing organism to the environment. The genes that the individual inherits are not, therefore, equivalent to predestination, but are amenable to the influences of the environment, and hence, to some extent, to human control.

Where the constitutionalists go wrong is in their claim that "structure determines function." Function is, of course, an aspect of structure, but as any elementary student of physiology should know, *the functions of structures assume their particular character according to the environment in which they operate* (*14*). The constitutionalists consistently fail to understand the importance of the environment, especially in human development, and this is the most fatal of all the criticisms of their work.

WITH WHAT KIND OF BEHAVIOURAL EQUIPMENT IS MAN BORN?

It is generally agreed that man is born free of those biological predeterminants of behaviour which characterize other animals. Man is born without instincts (*15*), without those psychological dispositions which cause other animals to respond in a particular manner to a particular stimulus accompanied by a particular emotion. The form of the animal's responses is predetermined; man has to learn the forms which his responses assume. While other animals are mostly creatures of instinct, man is the creature of habit — the habit which he acquires from his culture. But these habits are organized by his culture around a number of urges, drives or basic needs, as they have been variously called. These terms are the merest labels for physiological conditions, the exact nature of which is far from being known.

There is fairly general agreement as to the number and definition of basic needs. A basic need may be defined as a requirement of the organism which must be fulfilled if the organism and the group are to survive. The main basic needs are: oxygen-hunger, thirst, food, activity, rest, sleep, bowel and bladder elimination, sex, fear, and avoidance of pain. Malinowski has defined the concept of basic needs as "the environmental and biological conditions which must be fulfilled for the survival of the individual and the group" (*4*). It is important to note that this definition includes the group as well as the individual, and this inclusion constitutes one of the most significant departures from, and improvement upon, the old concept of "instinct." It constitutes an explicit recognition of the fact that man, if not all other animals, functions, if he functions at all, in relation to a group; and that, so far as human beings are concerned, functioning, that is behaving, apart from a group simply does not occur. When human beings behave socially it means that they have been socialized within a human group — if they have not been socialized within a human group, then they do not behave like human beings.[1] Indeed, the person becomes related to himself to the extent to which he becomes related to the group (*16*).

Malinowski, who was the first anthropologist to attempt a comprehensive theory of needs, set out the permanent vital sequences, as he called them, which are incorporated in all cultures, in a list from which we shall take only one impulse, as follows:

(a) Impulse — Hunger
(b) Act — Ingestion of food
(c) Satisfaction — Satiation

This kind of sequence is rather too elementary and, in fact, unsound, because Malinowski has failed to perceive that the act leading to satiation (here in the case of hunger) is an indissoluble part of the process of satisfaction, and because there is rather more involved in the actual sequences than Malinowski's order suggests. A list of basic vital sequences prepared by the present writer follows.

Warning Mechanism	Physiological Tension	Urge or Need	Satisfaction	
			Which Leads to	Homeostasis
Accumulation of CO_2	Oxygen-hunger	Intake air	Breathing	Oxygenation of tissues
Periodic gastric waves	Hunger	Ingest food	Ingesting food	Satiation
Dryness of mucous membranes	Thirst	Intake liquid	Intaking liquid	Quenching
?	Sex	Conjugate	Conjugation	Detumescence
Reduced organization	Fatigue	Rest	Resting	Restoration of muscular and nervous energy
Excess energy	Restlessness	Be Active	Activity	Reduction of energy to equilibrium
?	Somnolence	Sleep	Sleeping	Awaking with restored energy
Tonic disturbance	Bladder pressure	Micturate	Micturation	Tension removal
Peristalsis	Colon pressure	Defecate	Defecation	Tension removal
Autonomic activity	Fright	Escape	Escaping from danger	Relaxation
?	Pain	Avoid	Avoidance	Return to normal state
	Internal excitation	Craving	Neuromuscular act	Equilibrium

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[1] There are no examples of completely isolated human children — in spite of many published accounts to the contrary — but there are several recorded cases of children who have been almost completely isolated from human contact for several years (these cases will be discussed in a book now in preparation by the author); such children fail almost completely to develop as human beings, and in many cases are even psychically blind and deaf, unable to walk or run, and unable to make more than the most elementary sounds.

The warning mechanism is a minimum physiological change which provides the organism with cues enabling it to anticipate the full effects of depletion or excess. Thus, we generally drink before we become conscious of intense thirst, and indulge in activity long before we feel any intense need for it, and we breathe long before we feel the phobic stir, which precedes each breath we take, so faintly that we do not normally notice it (*17*). The warning mechanism or minimum physiological cue enables the organism to anticipate its needs before the latter become too disturbing. Forestalling behaviour therefore becomes possible (*18*). We are warned long before there is any tissue depletion or experience of excess. The intervals between the warning activity and biochemical depletion or excess vary, the margin of safety varying from a few seconds in respiration to hours in water balance. The greater the interval the longer are the psychological complications which can be developed. The extent to which psychological processes can influence the various warning mechanisms varies widely.

Since the warning mechanisms operate through a phobic-like anxiety, failure to obtain the necessary satisfaction of the need which develops serves to increase anxiety; as Kubie remarks, every basic need functions between the pressure of "normal phobic and normal compulsive psychologic processes which are the Anlage of all pathologic distortions" (*17*).

Under certain conditions the warning mechanism and the basic need may become detached from one another; the warning mechanism in the form of a sense of dryness, for example, may continue to operate even though the tissues are thoroughly hydrated. Or vice versa, there may be a considerable degree of dehydration without any sense of dryness or thirst. Such dissociations are usually pathological. Anorexia or chronic lack of appetite is a well-known example.

One of the prevailing myths of our Western tradition is the belief that the baby is born inheriting something of the ancestry of its lowly forbears, with respect not only to its physical but also to its psychological traits. The alleged "aggressiveness" of animal nature, it has been held, is in part inherited by the young *Homo sapiens*. Freudian and Jungian psychology assumes the innate aggressiveness of man, and civilization is regarded by both as a more or less unsuccessful attempt to keep this innate aggressiveness within bounds (*19*).

Freud's postulation of a "death instinct" is now generally discredited, but his use of the synonymous term, "the destructive instinct," still plays a considerable role in psycho-analytically influenced writings. This alleged "destructiveness" is identified with man's alleged inherited aggressiveness, and so one of the dominant views about human nature in our own day has become associated with the belief that man is inherently born aggressive.

For this viewpoint there is not a shred of supporting evidence. On the contrary, *all* the available evidence gathered by competent investigators indicates that man is born without any aggressiveness within him whatsoever. Professor Lauretta Bender, through whose hands have passed literally thousands of children, in her capacity as a child psychiatrist finds that, far from being inborn, hostility in the child "is a symptom complex resulting from deprivations which are caused by developmental discrepancies in the total personality structure, such that the constructive patterned drives for action in the child find inadequate means of satisfaction and result in amplification and disorganization of the drives into hostile or destructive aggression." "The child," she writes, "acts as though there were an inherent awareness of his needs and there is thus the expectation of having them met. A failure in this regard is a deprivation and leads to frustration and a reactive aggressive response."

Indeed, the development of the organism is toward maturation in terms of co-operation. Bender calls it "the inherent capacity or drive for normality." And she adds: "The emphasis on the inborn or instinctive features of hostility, aggression, death wishes, and the negative emotional experiences represent a one-sided approach which has led our students of child psychology astray."

Professor Abraham Maslow makes much the same points in an important article. Maslow writes: "Those human impulses which have seemed throughout our history to be deepest, to be most instinctive and unchangeable, to be most widely spread throughout mankind, i.e., the impulses to hate, to be jealous, to be hostile, to be greedy, to be egoistic and selfish, are now being discovered more and more clearly to be acquired and not instinctive. They are almost certainly neurotic and sick reactions to bad situations, more specifically to frustrations of our truly basic and instinct-like needs and impulses" (*21*).

Professor Gardner Murphy writes: "As we watch behaviour in early childhood, we no longer assume that each individual will inevitably push himself ahead and crave every toy or every attention he can get; instead, we begin to ask if there is something in our society that does not satisfy the child's needs and, therefore, makes it aggressive" (22).

The fact seems to be that aggressiveness usually develops in the child as a result of frustration, that is to say, the blocking of expected satisfaction. The infant expects to have its needs satisfied; if those needs are not satisfied it feels frustrated, and normally reacts with aggressive behaviour. It is now coming to be understood that aggression is, in effect, a technique or mode of compelling attention to, and satisfaction of, one's needs.[2] Such an interpretation of the meaning of aggressive behaviour in children puts a very different complexion upon the manner of handling it than has been customary in the past. Aggressive behaviour in all human beings most frequently represents a response to frustration (23); a response to the frustration of expected satisfaction. In this connexion the work summarized in Ashley Montagu's *On Being Human* (24), and more recently in the WHO report by John Bowlby on *Maternal Care and Mental Health* (25), should be consulted.

As the result of the work of a large number of investigators (whose research will be found described in the two last-mentioned books) it is now indisputably clear that the satisfaction of the child's needs by the mother or some substitute for the mother is necessary for the healthy physical and mental development of the person. Physical satisfaction of the needs of the organism is not enough; what is necessary in addition is the warmth, the love of another human being who is deeply interested in the welfare of the child.

It is becoming increasingly clear that the infant is born not only with the need to be loved, but also with a need to love; he is certainly not born with any need to be aggressive.

This view of human nature makes a very different picture from the traditional one, with its conception of man born with an aggressiveness which the process of socialization must suppress or eradicate. It is that view which rendered rationalizations about the "innate warlikeness" of man, and facile generalizations about man as a "brute," the stock in trade of every former authority on human nature. But modern research has shown that this view of human nature is erroneous. Man is not born evil or aggressive — he is rendered so. This being the case, it is incumbent upon us to realize that we can best change human nature for the better not by working on man's biological inheritance but by working on his social inheritance: by changing those conditions which produce disharmony in the person and corresponding disharmony in his society. As Professor Warder C. Allee has said: "Despite many known appearances to the contrary, human altruistic drives are as firmly based on an animal ancestry as is man himself. Our tendencies toward goodness, such as they are, are as innate as our tendencies toward intelligence; we could do well with more of both."

The school of evolutionary thought which preached the struggle for existence and the survival of the fittest gave a one-sided view of nature as a competitive "red in tooth and claw" process, and omitted almost entirely the factors of cooperation and mutual aid, which play so great a role in the ecology, the balance, of nature. The resulting view of nature was thus put badly out of focus, but upon it was erected a view of human nature which was as readily accepted as was the evolutionary theory of nature modelled on a *laissez-faire* industrial civilization.

Perhaps one of the most important of our conclusions is that never was there a stereotype more unsound than that enshrined in the view: "You can't change human nature." On the contrary, we find that man is the most plastic, the most malleable, the most educable of all living creatures; indeed, that educability is a species character of *Homo sapiens*. Man is the learning animal, and he is capable of learning and changing his views and his habits throughout his life.

Human nature, happily, is a great deal better in its promise than man has thus far realized in his performance.

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[2] I believe that the late Ian B. Suttie was the first to point this out in his important book, *The Origins of Love and Hate*, Kegan Paul, London, 1935. This book is, incidentally, perhaps the best and most original critique of Freudian psychoanalysis extant.

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Homeostasis, Society, and Evolution: A Critique

JULES HENRY

The biological principle of homeostasis is a powerful and attractive notion because of its completeness and also because of its applicability to systems other than the biological interactions from which it was derived. In this article Henry expertly describes and annotates the concepts which go into the principle. (The student may wish to relate these concepts to selection 48 by Strange.) But the major point which Henry develops is that applications of the principle to interpersonal and intergroup systems are not as clear cut as they at first appear. Although Cannon himself originally suggested such applications, he was not thinking of social systems as they exist, but as they might become after we understood them well enough to exercise controls. What we lack in the social systems is a criterion of what they ought to be — a baseline corresponding to physical health in the biological system.

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One of the attractive features of the theory of homeostasis as a physiological principle is its *completeness*. Actually, the complete theory is made up of roughly 15 statements about the functioning of higher animal organisms. It is not clear that all who use the word *homeostasis* are aware of these dimensions when they are analogizing from the homeostasis of the body to the functioning of society.

THEORY OF HOMEOSTASIS

As discussed in Cannon's book (*1*), homeostasis is related to the following 15 items.

1. *The fluid matrix.* "In the main, stable states for all parts of the organism are achieved by keeping uniform the natural surroundings of these parts, their internal environment or fluid matrix" (p. 287). By fluid matrix is meant the blood and other body fluids.

2. *The margin of safety.* The human body is not "set up with a niggardly economy," but there is much "allowance for contingencies." The body in most of the important aspects of its functions has more than it needs. We could get along with one kidney, one lung, much lower blood pressure than the "normal," and so forth. The body has resources far beyond those made necessary by ordinary living.

3. *The functions of storage and elimination.* The constancy of the internal milieu of the body is maintained not only through excess of vital organs, but also through the capacity of the body to store more than it needs — for example, blood sugar — and to rid itself rapidly of excesses — for example, water or carbon dioxide (pp. 207, 290, 293).

4. *The specificity of complementary interaction.* As an example, the process whereby the organism increases its supply of oxygen during muscular work is one involving mechanisms of great variety and specificity, operating in complex ways toward a common end — that is, providing the body with the unusual quantity of oxygen required by the work and finally restoring the organism to rest. During this process, many different mechanisms are set in operation, each one of which is triggered by a preceding change. Thus, for example, the increased carbon dioxide in the bloodstream stimulates the "respiratory center" in the medulla, which results in increased vigor of respiration, and in "pumping out the extra carbon dioxide in the alveoli." "When that has continued to the extent of reducing the percentage to the normal level of calm existence, the extra stimulation of the respiratory center subsides and quiet breathing is resumed" (p. 150).

5. *Defense.* In his chapter entitled "Natural defenses of the organism," Cannon states:

> In a sense the preservation of the constancy of the fluid matrix of the body may properly be regarded as a defense against unfavorable conditions which would arise if the constancy were not preserved. And there is little doubt that the mechanisms of homeostasis belong to the general category of protective functions. But there are special reactions of the organism, nicely adapted to dangers which might arise from the presence or attack of injurious external agents. . . .

Among such devices, Cannon mentions the various protective reflexes in the respiratory tract; the excessive salivation consequent on the placing in the mouth of some noxious substances; the vomiting reflex, and others. In connection with the system of defense, it is particularly important to take note of Cannon's phrase "*special* reactions of the organism *nicely* adapted to dangers . . . ," for here again we have the ideas of specificity and complementary interaction.

6. *The even course that involves the crucial concept of the baseline.* Many of the fundamental normalities or basic conditions of the human organism have been measured and are known: pulse and respiration rate, blood volume, blood sugar level, and so forth are known, and it has been demonstrated that the body functions in such a way as to maintain these conditions constant, or on an "even course." As Cannon says (p. 227), "In considering the homeostasis of blood sugar, oxygen supply, acid-base reactions and temperature, certain adaptive reactions were described which kept the body on an even course in spite of conditions which might have been deeply disturbing."

7. *Constancy as the necessary condition for freedom and independence.* This idea was taken over by Cannon from Bernard, whom he quotes (p. 38), " 'It is the fixity of the *milieu intérieur* which is the condition of free and independent life . . . and all vital mechanisms, however varied they may be, have only one object, that of preserving constant the conditions of life in the internal environment.' "

Cannon then says (p. 302):

> The pertinent question has been asked by Barcroft, freedom for what? It is chiefly freedom for the activity of the higher levels of the nervous system and the muscles which they govern. . . . The full development and ample expression of the living organism . . . are made possible by such automatic regulation of the routine necessities that the functions of the brain which subserve intelligence and imagination, insight and manual skill, are set free for the use of these higher services.

I think it can readily be seen that such a conception of the consequences of homeostasis provides an excellent biological underpinning for any liberal democratic theory of progress and explains in part why the concept of homeostasis has captured the imaginations of some scientists. The theory, however, can also serve as a vade mecum for imperialism — namely, if you want to hold on to your empire, keep it off balance in such a way that only the motherland can maintain it in a steady state. When the outlying possessions are able to regulate themselves, they will want to throw the mother country away — that is, they will want the freedom which their own self-regulatory mechanisms now permit them to achieve.

8. *The relation between external and internal change.* As Cannon says (p. 267):

> . . . states of the *external* environment, and also responses of the organism itself to situations in the external environment, are associated with disturbance of the *internal* environment. This personal, individual climate, which we carry with us, must not greatly change if we are to continue to be effective. For constancy of the internal environment, therefore, every change in the outer world, and every considerable move in relation to the outer world, must be attended by a rectifying process in the inner world of the organism. The chief agency in this rectifying process . . . is the sympathetic division of the autonomic system.

In this connection, Cannon mentions such things as the coagulation of the blood when blood vessels are opened, the constriction of the peripheral blood vessels in the presence of cold, and the increased action of the heart in high altitudes that results from the reduction of oxygen supply. These changes in the body, it will be noted, are highly specific; they are "pinpointed" to *particular events* in the outer world and set in motion by a particular neural agency, the sympathetic system.

9. *Automaticity.* (See also items 7 and 10.) In discussing "how the uniformity of the fluid matrix is preserved," Cannon says (p. 288): "A noteworthy prime assurance against extensive shifts in the status of the fluid matrix is the provision of sensitive automatic indicators or sentinels, the function of which is to set corrective processes in motion at the very beginning of a disturbance."

Here, indeed, is stated the essence of homeostasis: it works of itself — it is, as Cannon says, *automatic.* Crucial to physiological homeostasis also is that the mechanism is "set . . . in motion at the *very beginning* of a disturbance." On the *whole* the self-regulatory processes are set in motion before disturbance has gone too far. Sometimes, of course — for example, in gross injury or in disease — homeostasis cannot correct the disturbance of the constancy of the internal milieu, and in addition, sometimes the body can misinterpret the signals that come to it (2). But on the *whole* this automaticity does indeed work and does so from the beginning.

At this point it seems important to remind ourselves, particularly those of us who work in the behavioral sciences, that Cannon points out (pp. 288–289) that there are not a few cases in which we have no "clear knowledge of what the indicator is or how it works." Physiologists can see self-regulation taking place, but in some cases, even in the highly controlled field of physiology, they do not know the processes that carry it through.

10. *Resistance to change.* "If a state remains steady it does so because any tendency towards change is automatically met by increased effectiveness of the factor or factors which resist the change" (p. 299).

11. *The presence of spiraling effects.* The faster the blood flows, as in hemorrhage, for example, the more rapidly the blood will clot (pp. 44–45).

12. *Management of waste.* Not only does the body eliminate products it cannot use, but mechanisms are set in motion for the transportation and elimination of waste. Sometimes, as in the case of the capillaries, for example, the same mechanism carries in needed supplies and carries away waste.

13. *The preparation for struggle.* In the case of the emotions of rage and fear (pp. 227–228),

> Respiration deepens, the heart beats more rapidly, the arterial pressure rises, the blood is shifted away from the stomach and intestines to the heart and central nervous system, [and so on]. . . . The key to these marvelous transformations in the body is found in relating them to the natural accompaniments of fear and rage — running away in order to escape from danger, and attacking in order to be dominant. . . . The emotional responses just listed may reasonably be regarded as preparatory for struggle.

14. *The natural instability of the body.* Cannon says (pp. 286–288), "One of the most striking features of our bodily structure and chemical composition that may reasonably be emphasized

. . . is extreme natural instability. . . . The central problem in understanding the nature of the remarkable stability of our bodies, therefore, is that of knowing how the uniformity of the fluid matrix is preserved."

Thus Cannon starts from *instability*, and sets his task as that of understanding how the body remains stable at all. It will be immediately apparent to students of the behavioral sciences that his position is at 180 degrees from the sociology that assumes social stability ("equilibrium") and sets itself the task of understanding instability.

15. *The relative isolation of the internal from the external milieu.* This conception is best expressed in the language of C. Bernard, ". . . the environment . . . is separated more and more from the outer cosmic environment, by reason of the same organic development [toward freedom]. A living body . . . is . . . independent in its advance and modality." Bernard makes it clear that the organism's capacity to regulate itself is achieved by virtue of its relative insulation from the "outer cosmic environment" as he called it. This insulation is made possible by the existence of "a limiting surface membrane, the intactness of which is essential for the integrity of *le milieu intérieur*. Disruption of this barrier between internal and external environment is incompatible with life" (3).

Thus homeostasis has been empirically demonstrated to be a process which, operating from a *measurable baseline* (for example, normal pulse rate, blood sugar level, and so forth), works *automatically* through a system of *specific* and intricately *complementary* mechanisms that are controlled to a considerable extent by the autonomic nervous system as a *governing system* and implemented through *a specific medium*, the so-called "fluid matrix." Homeostasis makes it possible for an organism that is essentially unstable to *maintain itself at the maximum efficiency* possible for it at a given point in its life cycle, while it slowly changes in the direction of evolution and degeneration (aging), and until it has reproduced itself and brought up its young.

When we come, then, to consider the relevance of the concept of homeostasis to society, it behooves us to ask ourselves to what extent we can empirically demonstrate that society really duplicates analogically the mechanisms on which homeostasis depends: whether indeed society has specific self-regulating mechanisms, operating automatically from a definable baseline, and which tend always to hold society to a point of maximum efficiency.

SOME EXTENSIONS OF THE PHYSIOLOGICAL THEORY

Aside from applications in physiology and medicine (4), the concept of homeostasis has been utilized in psychology and psychiatry (2, 3, 5). Interesting as these extensions may be, however, they cannot be examined in his paper because my wish is to focus on the problem of the relevance of the concept of homeostasis to society.

Cannon himself was intrigued by the possibilities of the extension by analogy of his conception to human society, and the epilogue to *The Wisdom of the Body* is entitled "Relations of biological and social homeostasis." A few quotations will give a feeling for his attitude.

> Hardly any strong tendency in a nation continues to the stage of disaster; before that extreme is reached corrective forces arise which check the tendency and they commonly prevail to such an excessive degree as themselves to cause reaction. [p. 312]

> . . . the disturbances are roughly limited, and . . . this limitation suggests . . . the early stages of social homoestasis. [p. 312]

> . . . civilized society has some of the requirements for achieving homeostasis but . . . lacks others, and because lacking them it suffers from serious and unavoidable afflictions. [pp. 312–313]

> The distribution system, i.e., transportation, corresponds to the fluid matrix. Money and credit, too, correspond to the fluid matrix. [p. 314]

> In the complexity of modern social interrelations the strategic control would appear to reside in the devices for distributing goods, in commerce and the flow of money rather than in manufacture and production. [p. 317]

> The organism suggests . . . that the importance of stability warrants a specially organized control, invested by society itself with power to preserve the constancy of the fluid matrix, i.e., the processes of commerce. [p. 318]

> It appears, therefore, that any wisdom which the human organism has to offer to the social organism would be based on the proviso of a population which is adjusted to reasonably assured means of subsistence which is undisturbed by large increases from either local or foreign sources. [p. 319]

> Just as social stabilization would foster the stability, both physical and mental, of the members of the social organism, so likewise it would foster their higher freedom, giving them serenity and leisure, which are the primary conditions for wholesome recreation, for the discovery of a satisfactory and invigorating social *milieu* and for the discipline and enjoyment of individual aptitudes. [p. 324]

Thus in Cannon's thinking homeostasis became a plank in a political platform and a theory of social control. It would appear that, like so many theories of society that seek support in biology, and particularly in analogies with the human body, Cannon's theory tended toward conservatism; what is essentially sought is social stability and, in conformity with Bernard's earlier analysis of the conditions for stability, isolation — which, if one reads Cannon aright — becomes a parochialism free from population "increases from . . . foreign sources."

Meanwhile Cannon saw shrewdly enough that modern nations were not yet self-regulating, but he believed that as society evolved they would gradually become self-regulating. This confidence that human society is evolving in the direction of the further development of homeostatic mechanisms is carried forward by Emerson, the zoologist (*6*). Emerson was impressed by the marvelous mechanisms for internal control possessed by the social insects; for so perfectly regulated did these colonies seem that he came to consider homeostatic control in the social sphere as a goal of human evolution (*7*):

> These differences in the mechanisms of biological and social heredity are sufficient to separate the social sciences from the biological sciences on fundamental and valid grounds, but we err if these differences blind us to the analogous similarities implied by the term "society." Both human and nonhuman societies exhibit social division of labor, social integration, and social homeostasis. *And there is an increase in these characteristics in the genetic evolution* of animal societies and in the *cultural evolution of the human species.* [p. 344, italics mine]

> . . . if we state that there is nothing in common between the architecture of termites and man, we would be forced to coin separate terms and might fail to recognize the shared functional principles. Comparisons would be delayed. The *tendency toward increased homeostasis* would be inadequately seen, and there would be less understanding of the trends and factors of societal evolution, both in human and insect. [p. 345, italics mine]

> . . . an optimal balance between conservative and creative mechanisms is one of the homeostatic controls in the organism . . . [and] there is an optimal relation between social coordination and freedom of human individuals and . . . either carried to extremes would be harmful both to the individual and to the society. [p. 345]

> Progress and improved homeostasis seem to be nearly synonymous. [p. 348]

> This principle [of homeostasis] not only links physiology and sociology, but indicates the direction future evolution will take. [p. 352]

It is possibly not always the theorist's task to document his conjectures, and Emerson has taken this position; to the social scientist is left the task of discovering whether increase in "social homeostasis" can indeed be demonstrated throughout the milleniums of human culture and whether an "optimal relation between social coordination and freedom" can indeed be empirically established for modern nations. Meanwhile, it is important to note that for Emerson homeostasis has become a central assumption in a liberal American theory of progress (*8*).

In the social sciences, the stage was set for use of the homeostatic analogy by the concept of *equilibrium*, which was borrowed from classical mechanics and entered sociology through the writings of Pareto (*9*), Durkheim (*10*), and Parsons (*11*). Parsons has borrowed the language of Cannon for his most recent formulations. However, influenced by Pareto, he still uses the vocabulary of mechanics also (pp. 482–483):

> Theory relative to such [boundary-maintaining] systems, is directed to the analysis of the conditions under which such a constant system pattern will be maintained and conversely, the conditions under which it will be altered in determinate ways. This, we may surmise, is the fundamental basis for the assumption of our "law of inertia" of social process. [Footnote to p. 482: This conception is similar to that of homeostasis in physiology.] What the theorem does is to state the fundamental point of reference for the theoretical analysis of process in the social system. The analysis of the conditions or factors affecting motivational process is always stated in terms relative to this point of reference.

> The *problem* is always some version of the problem why, given a certain change in the relevant conditions, the constant pattern which is the point of reference is altered in a certain way or, conversely, why it fails to be altered in the face of certain alterations in the conditions. The latter question is always implicit in the problem structure, the problems of theory, that is, revolve about the conditions of maintenance and alteration of equilibria which are defined as empirically observed pattern constancies of a boundary-maintaining system. The essential point is that for there to be a theory of *change* of pattern . . . there must be an initial and a terminal pattern to be used as points of reference.

Here we have it, still somewhat in the language of Pareto but now also clearly in the frame of reference of Cannon and Bernard: the boundary, constancy, and the baseline and departure from and return to it. Thus a theory originally rooted in Newtonian physics is transformed into one inspired by contemporary physiology.

Parsons does not believe that it is necessary to explain the *maintenance* of a social system, but only the processes of deviation and control (pp. 204–205); a position that seems to me to be tautological. For if we ask: What is a "process which counteracts tendencies to change the system?" (p. 204), it seems to me that the answer must be a process that *maintains* the system. There is no such process, however, in Parsons' scheme, but only an *assumed* tendency of social systems, comparable to Newton's first law in mechanics (p. 204): ". . . the 'tendency' to maintain the interaction process is the first *law of social process* . . . [and] no *special mechanisms* are required for the explanation of the maintenance of complementary interaction-orientation . . . This assumption . . . may be compared to the first Newtonian law of motion . . . the law of inertia . . ."

In Parsons' theory, stability is the irreducible given (*13*), and it is deviation, its control, and the reequilibration of the system that need to be understood. Cannon, on the other hand, starts from the "extreme natural instability" of the body structure. It seems to me that one arrives at vastly different attitudes toward society depending on which one of these positions one takes with respect to it. If one assumes that society is inherently stable and orderly, then the jolts and insecurities of contemporary life with all its *disorderliness* seem endlessly unexpected and disquieting, and one struggles ceaselessly to bring about an order the exact nature of which it is difficult to discern. On the other hand, if one assumes that society is inherently unstable, then one accepts disorderliness as natural in a strict sense and attempts to live in terms of perceived patterns of conflict and instability.

TEST CASE

Since the value of a theory inheres in its ability to help us interpret data, let us take a body of data, and see if the theory of homeostasis applies. Since, as applied to human society, the theory should help at the most elemental as well as at the most complex level, let us start with the most elemental — a mother nursing her newborn infant (*13*).

> The mother was lying on her back in a slightly raised position when the nurse carried the baby in and laid it on the bed beside the mother. The mother took the bottle and put the nipple in the baby's mouth and said, "Every time he comes in here he is asleep." The baby moved its arms. The mother took the nipple out in five seconds. Mother rubbed baby's mouth with nipple, patted baby's buttocks and shook him vigorously. Baby moved its arms near face. Mother pulled baby's hand away from face. After two attempts the nipple was successfully inserted after 47 seconds more of the nursing period had elapsed. Then the mother said, "He is not doing anything. Can they, when they are asleep?" Observer replied, "Not very well." As baby started sucking mother said, "There he goes." Baby sucked four seconds. Mother jiggled nipple and patted baby's buttocks. Baby moved its arms and mother said, "Oh, sleepy head." Mother jiggled nipple, baby moved arms again, mother said, "Come on!" and laughed. She patted baby's back and pulled baby's arm away from its face. The mother patted baby's hair, said "Come on!" shook baby, and said, "He just doesn't want to wake up." She rolled the baby from side to side. Baby moved hands over top of nipple. Mother twirled nipple, and rolled over further on her side. Baby sucked for two seconds, made a wry face, and mother said, "Hey, wake up!" She jiggled nipple again, and said, "He's having a hard time making out." She jiggled baby's arms and said, "Come on, sleepy head!" To the observer she said, "I never see him with his eyes open, hardly." She rolled the baby from side to side, jiggled the nipple, and said, "Come on, come on!" Baby moved its arms and mother said, "You never get any down you, you sleep so much." She pulled the baby's arm, and said, "Come on!" Baby moved arm. Mother pulled nipple out . . .

(Six minutes had elapsed since the beginning of the nursing period.)

It will be recalled that Cannon was able to refer a very large number of body processes to specific homeostatic mechanisms, within which there is a network of complementary triggering interrelationships. Our problem in the present case, then, would be to discover, within an empirically ascertainable homeostatic process, the specific complementary relationship among such things as: (i) the baby's being delivered in a hospital instead of at home; (ii) feeding the baby every 4 hours for 45 minutes, as prescribed in this hospital; (iii) the mother's being on a bed (instead of on the floor, for example); (iv) use of a bottle (instead of the breast); (v) the presence of the salaried, trained nurse as a mother surrogate (instead, for example, of the mother's or the husband's sister); (vi) the mother's determination to keep the baby's hands from its face; (vii) patting the baby on the buttocks; and (viii) use of the expression *sleepyhead* and other verbalizations. To the student of culture it is, of course, obvious that what is going on here is not understandable in terms of any absolute criterion of homeostasis, but must rather be referred to a *cultural* milieu. That is to say, if the events occurring in the nursing situation are to be understood in terms of a homeostatic hypothesis, we must realize that the milieu in the present case is the particular culture and that the events must be referred to some homeostatic processes peculiar to this culture.

Let us focus on the feeding schedule, and see where such a consideration will get us.

The regulations of this hospital prescribe for neonates 45-minute feeding periods every 4 hours. The question arises *whose* homeostasis is being maintained by this procedure: the baby's? the mother's? the hospital's? American society's? or the world's? The baby would eat when hungry and sleep when sleepy if permitted to do so, for its physiological homeostasis would take care of that.

In all the protocols of neonates taken in this hospital, baby is seen to drift off to sleep repeatedly, but to be awakened and obliged to suck. Thus, in social interaction at this elemental level, the baby's own self-regulatory mechanisms are ignored. If homeostasis operates at all, it has little to do with baby's self-regulating system.

Maybe the mother is maintaining her own homeostasis; maybe something would happen to upset her even course if she did not give baby a certain amount of milk specifically during the 45-minute periods that are made to occur by the hospital every 4 hours. If this were true, it would mean that what was not natural homeostasis for baby is homeostasis in some way for mother. Hence, within this biosocial system the homeostatic mechanisms of mother and baby would then appear to be opposed — at least in part. Since most of the babies in this sample are bottle-fed, physiological homeostasis of the mothers cannot be in question. Since the baby's, on the other hand, seems to be ignored, we must search for some explanation of the behavior just described within some very general sociological analog.

For example, we might ask: When the mother feeds the baby as stipulated, of what homeostatic social system is she part? We may approach the problem, it seems to me, by asking: Why does the hospital run baby-feeding this way? When we ask this question we must change our position as observers, for we then are no longer studying the mother-baby system, but the more complex mother-hospital-baby system. That is, two things have happened: (i) we see the mother and baby as part of the larger system; and (ii) we see that the hospital has interposed *its* system — homeostatic or otherwise — between mother and baby. In an almost literal sense, it becomes a question of who is feeding whom? Is the hospital or the mother feeding the baby? And is the hospital feeding the mother or is the mother feeding the hospital — that is, keeping the hospital going by obeying its rules?

In order to study this more complex system, we must know something about its properties in order that we may know what homeostasis means when applied to it. Since a modern hospital in a large city is itself a complex social system, full understanding of the new system (mother-hospital-baby) involves us in a study of interrelationships that expand rapidly outward. Some of the factors involved in understanding the larger system follow.

1. This maternity hospital is part of a large medical center that must be run according to plan.
2. A baby in our culture is a biosocial nonentity without inherent powers or virtue. Hence it is readily subordinated to a larger "plan."
3. The hospital embodies a tradition — both general and also specifically medical — of efficiency, one important component of which is routine.
4. This hospital, like so many others, is insuf-

ficient for the needs of the surrounding population — a condition characteristic of the nation as a whole, at the present time, given the present birthrate.

5. Since babies often lose weight immediately after birth, babies are not expected to leave this hospital until they have gained back to their birth weight.

Thus, in ignoring baby's own self-regulatory mechanisms, society seems to be attempting to regulate itself, as follows. (i) Permitting the baby to indulge its own self-regulatory tendencies would upset the schedule of the medical center. (ii) If the schedule were upset, the employees' — everyone from the director to the orderlies — need for simplification of functioning would be interfered with. On the other hand, were the birthrate to decline sharply, pressure on hospital facilities would diminish, and the maintenance of rigid hospital routine might appear less urgent. In this respect, the hospital authorities would be obeying a law of human behavior, that as anxiety diminishes rigidity decreases also. (iii) Were baby not treated as a biosocial nonentity, this would be contrary to such ancient Anglo-American precepts as "spare the rod and spoil the child," and thus, perhaps, do some violence to the ethos of our striving, thrifty folk. The present movement among more "enlightened" pediatricians away from rigid schedules thus would seem to be related to changing attitudes toward infants — toward considering them "human beings in their own right" — as much as, or perhaps more than, it is related to any new scientific knowledge of what makes a good human machine (*14*).

Now let us look at some of the things these mothers say to their babies in the hospital, as they try to feed them and to quench their thirst (*15*). The expression they utter most often is "Come on!" — for example, "Come on and suck"; "Come on and wake up"; "Come on and take some more." Next in frequency is "Wake up," or some related phrase, followed in order by utterances pertaining to speed or quantity of intake, utterances in which the mother's wishes are opposed to those of the baby, utterances pertaining to achievement, work, success of baby or mother, and finally a small group of miscellaneous utterances. Since the responses of these white (*16*) mothers are relatively uniform in this situation, I have inferred that they are determined by certain uniformities in previous experience and that they are set off by cues emanating from the hospital environment — cues such as the baby's being brought to the mother from the nursery every 4 hours, the mother's being told that the baby should not go home until it has gained back to its birth weight, the urging of the nurses, and so forth. It can be inferred, therefore, that much of what the mothers do and say to their babies is by way of reduction of anxiety — anxiety to conform to the routine of the hospital. Thus the baby's physiologically determined homeostasis is altered by way of drive reduction in — that is to say, by way of the "homeostasis" of — its mother.

The matter, however, is still more complicated, for the utterances of the mother revolve around certain values in our culture — achievement, work, dominance, quantity, and the importance of failure and success, for example. These in turn are related to the importance of an expanding industrial order. Thus in a hospital, an institution of our culture, the environment of the baby obliges the mother to shove the cultural ideas down the baby's throat. When this is done, the hospital, and American society as a whole, are enabled to go on being *what they always have been.* This circumstance might conceivably be brought analogically within the conception of homeostatic control, but whether it has any relationship to optimal function, maximum human happiness, or even to the survival of the commonwealth, is an open question.

This is an important issue when we come to consider extension of the original conception of homeostasis to scientific fields outside physiology, for the conception of homeostasis as used with respect to the body involves two ideas, "normal" state and state of maximum efficiency. That is to say, the goal (*17*) of body homeostasis is to maintain the organism in a steady state, normal state, and state of maximum efficiency all at the same time. For most states outside the body, therefore, it does not seem to me that the conception applies; for on the whole society strives to maintain itself *as it is,* and "efficiency" generally turns out to be some sort of operating constancy that does no violence to traditional motivations, however conflict-producing they may appear. I have written one book (*18*) about a tribe whose "normal" state was self-destruction, and a number of papers about another whose "normal" state was one of great tension revolving around food, one of the primary factors in physiological homeostasis (*19*).

There is certainly one aspect of Cannon's theory that can be applied to society: Who would deny that society has processes aimed at resisting change? From my present position as observer, therefore, it looks as if in the hospital just discussed, baby's inherent physiological process is a menace to the social order, and hence the hospital must do what it can to alter the baby's way of life.

Before closing this section, let us return to the original summary of the empirical findings entering into the theory of homeostasis in order to see to what further degree we may err in uncritical use of the theory. Let us consider, for example, the "baseline" (item 6). In some cases it can be ascertained within seconds that something is wrong with the body, for our instruments, or even our fingers on a pulse, tell us that the organism has departed from its normal state or baseline. How shall we determine the baseline for society? We are obliged either to accept the present state as baseline, and say, for example, that the present population represents the norm from which deviation will be considered a danger sign; that the present distribution of wealth is the norm from which deviation will be considered a danger sign; that the present regulation of affairs by the Congress, President, and Supreme Court shall be the norm; and so on. And if we brush such suppositions aside and say we obviously are not so hidebound and status-quo hungry, but that we rather think of homeostasis in Emerson's terms — as ever-improving — we still have to ask: Where *shall* the baseline be? If we do this, we start a guessing game about the future.

Where in society can we locate the principles of automaticity and complementary interaction? It will be borne in mind that the warning signals issued by the body are on the whole specific and compelling in their force. What warning signals tell us that a society is bound for destruction; and if and when we get them, are the signals indeed compelling? Is war always "bad" in the homeostatic sense? Are our own wars indeed always "good" wars in the same sense? How do we know when to *stop* fighting? It is to be remembered that the body sets its homeostatic processes in motion at the very *beginning* of the destabilization effects. Does human society do this, or do we wait often until it is too late? Where is the mechanism that *automatically* compels us to take action against political corruption? Or, indeed, is political corruption "bad" for the body politic in the long evolutionary run between now and the time we have achieved nearly perfect "social homeostasis," as Emerson calls it? Of course, nobody cares about evolution when it comes to political corruption; one cares only whether it helps him or harms him at the moment. When we are faced with these questions, it seems to me that if we are firm believers in some ultimate homeostasis as the goal of society all we can do is sit back and say, "It is all homeostatic in the long run."

Let us take next the problem of complementary interaction. Consider the case of a Pilagá Indian who keeps some of his food, although according to the dictates of the society he ought to give it away (*19*). If he gives all his food away he will starve; but when he keeps enough to feed himself, he is frightened because he believes that those to whom he has not given food will sorcerize him. Can we, without taking into account the great burden of anxiety and hostility the Pilagá carry with them because of these very threats of sorcery, assume that Pilagá society is a "homeostatic" one just because threats of sorcery *do* manage to get food distributed? The complementary interaction between withholding food and anxiety does not always work; and even when it does, it creates stresses in the society that are damaging to interpersonal relations. It is true that, for many social events, roughly complementary processes can be found; but we cannot speak of homeostasis if the process works one day and not the next; if it is sometimes on time and sometimes late; or if it can build society up and break it down at the same time.

For such reasons, and because I have fortunately been able to document so well the history of the Kaingáng Indians' self-destruction (*18*), I cannot agree with Norbert Wiener's guess that "... small, closely knit communities have a very considerable measure of homeostasis; and this, whether they are highly literate communities in a civilized country, or villages of primitive savages" (*20*). On the other hand, we are in agreement in thinking that "One of the most surprising facts about the [modern] body politic is its extreme lack of efficient homeostatic processes" (p. 185); and that with regard to "the anarchy of modern society ... [the] optimistic feeling that there must be some way out has led to an overevaluation of the possible homeostatic elements in the community. Much as we may sympathize with these individuals, and appreciate the *emotional* dilemma in which they find themselves, we cannot attribute too much value to this type of wishful thinking" (p. 189, the italics are mine.) As far as I am concerned, the mathematician has put his finger on the dilemma: it is an emotional one; a hunger for order in an apparent chaos; and a passionate wish that there be *some* way of bringing society to an imaginary stability it has never had, where people can relax in peace.

HOMEOSTASIS AND EVOLUTION

Good homeostatic controls — ones that work automatically in a compelling way, to bring a given entity back to a discernible baseline of maximum operating efficiency — are genetically determined where they occur in the animal world. The human body is a perfect example at the organ level; communities of social insects are good ones at the social level. But once we get outside the human body, mankind has no genetically determined means for assuring homeostasis. If he did we would find the *same* ones wherever we find man, whether on the shores of the Mississippi, on the steppes of the Soviet Union, or on a coral atoll peopled with brown folk with frizzy hair in the South Pacific.

But we do not find such uniformity. Given the need to regulate his social life, man is everywhere an improvisor; sometimes his compositions turn out well, often they are bad, and his society then limps along like that of the Pilagá or the contemporary "civilized" world, or else wipes itself out. Kaingáng is one society whose history was written during the mid-course of its self-destruction; how many societies have perished in this way before their histories could ever be written? What we have today are the *remains* of human society through the ages: those societies that have *up to date* successfully coped with the problem of self-regulation. But who shall say that this will continue; or that it represents "efficient" adaptation, or an adaptation more efficient than what existed, let us say, two milleniums ago? Who shall say that the Solonic reforms were less "homeostatic" than those of the Democratic New Deal in the United States? The essential issue with regard to society is that man should be able to perfect his own interpersonal relations; there is no indication that he is a better hand at it today than he was at the dawn of recorded history. The evidence is lacking that human society has móved at all in the direction of the stabilization of interpersonal relations. What is not lacking is evidence that human society, by virtue of the total absence of genetically determined mechanisms for governing interpersonal relations, is *unstable*; and it is at this point, so it seems to me, that sociology and biology join hands in a common approach to the problem of the physical evolution of man.

As I see it, the crucial difference between insect societies and human ones is that whereas the former are organized to achieve homeostasis, the organization of the latter seems always to *guarantee and specifically provide for instability.* And this is the hub of the matter from the standpoint of human evolution: life stresses bring about important physiological changes in the human organism. These can become hereditary through selective processes, and only organisms that can adapt to the stresses and the ensuing changes will survive. But since human society and culture determine the nature of the stresses, and since human society is unstable, the stresses on the organism are always changing. Hence physiological adjustments are always changing, and hence biological selection is always taking place in terms of the changing stresses that are produced by the perpetual instability of human social systems. Thus we reach the conclusion that *man evolves physically in terms of a perpetually unstable social life,* as well as in terms, perhaps, of inherent tendencies of the organism itself to change.

This position may be made somewhat more explicit through the following model: Let us assume that P/R stands for a specific, relatively constant ratio of rewards to punishments in a relatively homogeneous society (*21*). This ratio of rewards to punishments acts upon the organic systems of the population in such a way as to produce a relatively stable response set a, in the population (*22*). This set then delivers negative feedback to maintain the configuration P/R relatively unchanged over a finite period of time. Should something happen to change the configuration to P'/R' or B, the population now has only a with which to deal with the new conditions. At this point a nonexhaustive catalog of the possible events in the system is as follows: (i) a changes promptly to b, the necessary new set, so that the system is maintained under the new conditions; (ii) a does not change, and thus delivers feedback that tends to change B back to A; (iii) a and B interact in such a way as to drive each other to ever wider and wider divergence. This would occur, for example, where, under one set of conditions a relatively weak attack (punishment) would elicit a relatively weak but successful self-assertion a. Change in circumstances now brings a heavier attack B, which produces not a, but b, which is submission. But b now provokes a still heavier attack C, which results in c, which is still greater submission. Continuation of the process forces the attacked organism to leave the field (flight or death).

Obviously the sets that we find in human society are more complex than this; they include such phenomena as tendencies to colic in infants, asthma, ulcers of the gastrointestinal tract, hypertension, and so on. All these are diseases of adaptation (*4*), the products of socially engendered stresses developing on the basis of the inherent tendency of society to instability, and hence of importance for the understanding of the evolutionary process. *The early development of colic, asthma, rheumatic heart, and so on in our children is not of medical interest alone: these diseases are phenomena of evolution.*

SUMMARY AND CONCLUSIONS

The kinship systems and obligations of nonliterate peoples, religious dogmas and hierarchies, police forces, and actuarial systems are all mechanisms of social control. They are devices whereby men, once having established their social life, seek to prevent it from falling apart. These are the empirical realities of social life at the human level, and no one would deny that human beings strive to prevent the society in which they live from becoming disorganized. It is another matter, however, to urge that processes of control are *ineluctable* in their implementation, that they tend to maintain society at the level of highest efficiency, and that the movement of mankind is toward greater and greater "social homeostasis"; for in the case of any empirical test such conditions cannot be demonstrated. Furthermore, so it seems to me, one cannot develop a cogent theory of human evolution on the hypothesis of social stability, but one can do it easily on a hypothesis of social instability.

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SUGGESTIONS FOR FURTHER READING

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PART IX *Behavior Can Be Controlled*

JUST AS ENGINEERING IS BASED UPON PHYSICS, MEDICINE UPON BIOLOGY, NAVIGATION upon astronomy, and agriculture upon botany, so some technological branches of the behavioral sciences are based upon psychology. Frequently the connection between the basic science and its technological offspring is not sharply defined, and the exact point at which the basic aspects drop out and the technological applications are picked up is not clear. There is much overlapping. Furthermore, many technical fields of specialization draw upon two or more basic sciences, and a single basic science may contribute to more than one technology. Medicine, for example, is based upon physiology, anatomy, biochemistry, physics, and several other sciences, all of which exist as basic sciences in their own right. A medical doctor is usually a practitioner or technologist, although persons with the MD degree frequently engage in fundamental research.

The element of control in the behavioral sciences has been mentioned in earlier parts of this book, but it is particularly pertinent to discussions in this last section. Any technology involves the element of *control* — control over objects, persons, or events. Control depends on being able to make successful predictions from information concerning antecedents, that is, existing conditions. When we have made successful predictions sufficient in number to permit us to have confidence, and when we can manipulate the antecedents, then we are in a position to exercise control. Control is the primary interest of the applied scientist or technologist, whereas understanding is the primary interest of the basic scientist.

However, control is no simple matter when we are dealing with human beings. We as a people live in a culture based upon freedom and independence. We have inherited an intellectual atmosphere of individual or self-responsibility and freedom of action within the limitations of group living. Each of us *feels* free of causal antecedents for our behavior. We even may resent the idea that our behavior is controlled. We think that we make independent, self-directed judgments about what we should do, whom we select as friends, where we shall live, what we shall do with our lives. On the other hand, scientific psychology gives evidence that human behavior, like all natural phenomena, is determined by causal antecedents. Even when the determiners are not known, the scientists believe in their presence and their ultimate discovery.

How can these opposing notions exist? Are they not contradictory? The first two selections in Part IX present some answers to these questions. The answers differ from each other, and from still others that have been proposed. Before one can accept, on a logical basis, the notion of control, he must come to some kind of solution to the issue of determinism versus freedom. Perhaps the solution of Grünbaum, the philosopher, or of Boring, the psychologist, will satisfy the reader, or perhaps they will stimulate him to seek other solutions.

Psychologists have found that their ability to control or at least to modify behavior has progressed to the point where they are in demand in a wide variety of technological roles. Rogers describes in selection 60 some of those areas where he feels the greatest advances have been made in control. Havemann's article which follows tells about the services of psychologists in three technological settings. Selection 62 shows the potentialities and limitations of vocational guidance. One of the newest technological fields, human engineering, is discussed by Mead and Wulfeck. More than half the members of the American Psychological Association are employed in some kind of psychological practice. The largest group is in the field of clinical psychology and counseling, seeking through the control of behavior to assist individuals with personal problems in mental hygiene clinics, vocational guidance bureaus, marriage clinics, prisons, mental hospitals, or other institutions, or sometimes in private practice. The work of this group is represented in the remaining selections of Part IX.

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Causality and the Science of Human Behavior

ADOLF GRÜNBAUM

Critics of behavioral science have at times been rather extreme in their claim that human behavior can never be subjected to scientific inquiry because behavior is not predictable. Throughout the sections of this book of readings there have been presented frequent examples of the orderliness of behavior and the discovery of many of its determiners. Thus by evidence and implication psychologists deny the charges of the unpredictability of behavior. In this selection Dr. Grünbaum develops the thesis of determinism in behavioral science. He examines four arguments which have been made against the existence of cause-effect relationships in human behavior, and then answers them one by one. The distinction between fatalism and determinism is especially helpful in clarifying thinking on this problem.

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It is not uncommon to find that even those who have complete confidence in the continued success of the scientific method when applied to inanimate nature are highly skeptical of its applicability to the study of human behavior. Some go so far as to assert quite categorically that the methods of the natural sciences are in principle incompetent to yield predictions of man's individual or social behavior. Thus, for example, Dilthey and his followers in the *Geisteswissenschaften* movement [1] insist on the methodological autonomy of psychology and the social sciences, claiming that intelligent goal-seeking, which is so characteristic of man, calls for a method differing *toto genere* from that of the physical sciences.

Several important arguments have been offered against the hypothesis that cause-effect relationships exist in human behavior. These arguments are intended to deny the possibility of making the predictions which only the existence of such relationships would render feasible. In this article I shall attempt to show that the arguments in question are invalid and that there are good reasons for accepting the causal hypothesis against which they are directed. Many of the ideas to be discussed here have been previously outlined or developed by other authors in diverse contexts; wherever possible, references are given to these writings.

Before analyzing critically some of the reasons which have been given for supposing that human behavior is inherently unpredictable, I wish to point out several important consequences of this widely held belief, and also of its denial. It is essential to state explicitly what these consequences are, since few of the proponents of this doctrine realize all of its implications.

If human behavior, both individual and social, does not exhibit cause-effect sequences, then the scientific method is essentially irrelevant to the elucidation of the nature of man, and both scientific psychology and the social sciences are permanently barred from achieving the status of sciences. This conclusion follows, since it is the essence of a scientific explanation in any field outside of pure mathematics to "explain" a past phenomenon or predict a future event by showing that these are instances of a certain law (or laws) and that their occurrence is attributable to the fact that the conditions for the applicability of the relevant law(s) were satisfied. Therefore, scientific or rational learning from past experience consists in ascertaining causal regularities from which to anticipate the future. Accordingly, to deny the existence of uniformities in human behavior, both individual and social, is to assert that significant lessons cannot be drawn from the past and that man's future is capricious and elusive. Nevertheless, some historians and social scientists tell us that the absence of causal law is the distinguishing feature of their subject as contrasted with the natural sciences. In the same breath, they maintain that the only way in which individuals and nations will become manageable is by a drastic intensification in the cultivation of the social studies. It is plain that this position is untenable. For nothing can be learned from history regarding the wise conduct of international relations, if no such wisdom is to be found in history. The distinction between wisdom and foolishness in practical affairs first becomes meaningful through the existence of cause-effect relationships in human behavior and by reference to the predictions which the existence of these relationships makes possible. Rules for managing individuals and nations can be based only on causal laws which tell us that *if* such and such is done, it is likely that the outcome will be thus and so, either in all cases or in an explicitly stated percentage of cases. It is useless to bemoan the great gap between our mastery of physical nature and our scientific understanding of man, if one denies the existence of the conditions which alone would make a scientific analysis of man possible. Only if human behavior does display some kind of causal law is it significant to emphasize the need for closing the dangerous gap between man's control over physical nature and his scientific knowledge of himself lest he destroy himself.

By contrast, the assumption that causal laws are discoverable in human behavior presents enormous possibilities. For in this case we can ask the social scientist to ascertain what means will bring about given ends. Thus it is possible to get a factually true rather than an emotional answer to some of the burning questions of our time. For example, we could hope for an authentic answer to the question, What system of organizing economic relationships will in fact lead to the maximum satisfaction of certain types of human needs? Whatever the answers to such questions, they would merit the assent of all rational men who share the same goals. To be sure, the history of physical science does record the defiance and acrimony evinced by men whose theories failed to be confirmed by the evidence. Nevertheless, we have learned to reject physical theories which fail to pass the test of observable fact, no matter how ingenious the theory or how dear it may be to our hearts when first propounded. For this reason the history of physical science is in a sense the history of discarded theories. What an advance toward sanity it would be, if it were equally generally accepted that theories of human nature, like physical theories, need careful, disciplined checking through observation. In our time, the ordinary person is very much aware of the need for scrupulous care in ascertaining the facts of nature but will hold forth dogmatically and evangelically about the alleged facts of "human nature." Despite the serious divisions among mankind today, most scientific knowledge concerning inanimate nature commands assent among thinking men everywhere. It would seem, therefore, that scientific knowledge of man, specifying the requirements for attaining given ends, would also merit such universal assent. In so far as this assent would actually be forthcoming, it would constitute a partial step toward human brotherhood.

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[1] In the latter part of the nineteenth century, W. Dilthey spearheaded an influential movement whose representatives claimed that the theoretical task of the natural sciences is fundamentally different from that of the social sciences and humanities. The aim of the natural sciences was said to be generalization, whereas the social sciences were held to seek the articulation of individuality.

So much for the implications of rival answers to the issue under discussion. Let us now deal directly with the merits of the answers themselves.

ARGUMENTS AGAINST CAUSALITY IN HUMAN BEHAVIOR, AND THEIR REFUTATION

There are four arguments which I wish to consider against the hypothesis that causality is present in human behavior. These are:

1. Human behavior is not amenable to causal description and therefore not predictable, since each individual is unique and not exactly like anyone else.
2. Even if there is a causal order in the phenomena of human behavior, it is so complex as to elude discovery permanently.
3. In the physical sciences, a present fact is always determined by past facts, but in human behavior present behavior is oriented toward future goals and thus "determined" by these future goals.
4. If human behavior were part of the causal order of events and thereby in principle predictable, it would be futile to attempt to make a choice between good and evil, meaningless to hold men responsible for their deeds, unjust to inflict punishment, and naive to take seriously such remorse or guilt as is professed for past misdeeds. In short, the argument is that to assume the principle of causality in human behavior is incompatible with the known fact that people respond meaningfully to moral imperatives.

In the following pages I shall try to show that all four of these arguments are the result of superficial or specious analysis. The fourth has been by far the most influential and was invoked in the pages of this journal a few years ago (5).

ARGUMENT FROM THE UNIQUENESS OF HUMAN INDIVIDUALS

This objection to the possibility of constructing a scientific psychology rests on several misunderstandings of the meaning of causality in science. To remove these misunderstandings it must be pointed out that *all* particulars in the world are unique, whether they are physical objects like trees, physical events like light flashes, or human beings. The mere assertion that a thing is a particular, means that it is in one way or another unique, different from all other objects of its own kind or of other kinds. Every insignificant tick of my watch is a unique event, for no two ticks can be simultaneous with a given third event. With respect to uniqueness, each tick is on a par with Lincoln's delivery of the Gettysburg address! It is clear, however, that the uniqueness of physical events does not prevent them from being connected by causal laws, for present causal laws relate only *some* of the features of a given set of events with *some* of the features of another set of events. For example, frictional processes are accompanied by the development of heat in so far as they are frictional, whatever else they may be. A projectile fired under suitable conditions will describe a parabolic orbit regardless of the color of the projectile, its place of manufacture, and so on. Since the cause-effect relation is a relation between *kinds* of events, it is never necessary that all the features of a given cause be duplicated in order to produce the same kind of effect. It follows that when scientific psychologists assume the existence of causal laws for human behavior, this standpoint is not incompatible with the existence of great individual differences among men, nor does it infringe on the uniqueness and dignity of each particular person.

Every individual is unique by virtue of being a distinctive assemblage of characteristics not precisely duplicated in any other individual. Nevertheless, it is quite conceivable that the following psychological law *might* hold: If a male child having specifiable characteristics is subjected to maternal hostility and has a strong paternal attachment at a certain stage of his development, he will develop paranoia during adult life. If this law holds, then children who are subjected to the stipulated conditions would in fact become paranoiacs, however much they may have differed in other respects in childhood and whatever their other differences may be once they are already insane.

A variant of the argument against scientific psychology is that no psychologist can ever feel exactly like each of the diverse people whose feelings and behavior he is trying to understand. This form of the argument contains an additional misconception of the kind of understanding or explanation that is sought by science — the impression that in order to explain aspects of human experience or behavior scientifically, the psychologist must himself directly have the experience in question in all its complexity. One who objects to scientific psychology on these grounds virtually equates scientific understanding with genuinely empathic understanding. To understand a phenomenon scientifically, however, is, in the first place, to know the conditions necessary for its occurrence. A physician interested in understanding cancer (including the psychic consequences of that disease) is not interested in becoming a cancer victim himself but only in knowing the conditions associated with the occurrence and non-occurrence of cancer. Strictly empathic understanding may have great heuristic value and sometimes aesthetic value as well. However, from the standpoint of achieving scientific understanding and making the predictions which such mastery makes possible, the empathic method in psychology and in history (Dilthey) is quite insufficient.

THE ARGUMENT FROM THE COMPLEXITY OF HUMAN BEHAVIOR

This argument, it will be recalled, is to the effect that human behavior involves so complex a proliferation of factors that it is futile to attempt to unravel them. A glance at the history of science will deprive this point of view of such plausibility as it may possess. Consider what a person advancing such an argument about psychology today would have said about the physics of motion before the time of Galileo. Probably he would have said that it is hopeless to attempt to reduce the vast diversity of terrestrial and celestial motions to a few simple laws of motion. Before the rise of scientific chemistry, this kind of person would have dismissed the possibility of reducing the seemingly unsurveyable variety of substances in nature to some 96 elements. This argument rests its case on what is not known, and therefore, like all such arguments, it has no case.

THE ARGUMENT FROM THE "DETERMINATION" OF THE PRESENT BY THE FUTURE IN GOAL SEEKING HUMAN BEHAVIOR

If a person is now taking action toward the realization of a future goal, it is argued that the immediate action is the effect of a future cause — a kind of causation not encountered among physical phenomena. The answer to this contention is that, not the future goal-event, but rather the present expectation of its realization causally controls forward-looking behavior. Indeed, the goal sought may never be attained. Moreover, both the motives for achieving the given goal and the contemplation of action in its behalf function as antecedent conditions in the same way as the causal factors in physical phenomena. Thus in motivational situations causal determination is quite unaffected by the ideational reference of motives to the future (3, 4).

THE ARGUMENT FROM MORAL CHOICE

The name "determinism" is applied to the thesis that all phenomena, including those of human behavior, fall into causal patterns. This formulation of determinism is logically objectionable in some respects, but it will suffice for this discussion. It is clear that determinism is one of the key (regulative) principles of all scientific research. The denial of determinism is called "indeterminism," and the indeterminist argument from moral choice to be considered here has been summarized by a critic somewhat as follows (8): If determinism is true, then my will also is always determined by my character and my motives. Hence I do not make free choices and should not be held responsible for my acts, since I can do nothing about my decisions and cannot help doing what I do. If the determinist is right, I have not chosen either my motives or my character; my motives come to me from both external and internal causes and my character is the necessary product of the influences which have been effective during my lifetime. Thus determinism and moral responsibility are incompatible. Moral responsibility presupposes freedom, that is, exemption from causality.

The question before us is whether the argument of the indeterminist is valid. Before arguing that the answer to this question is emphatically in the negative, I wish to distinguish between two types of determinism and attempt to show that they must each be objectionable to the indeterminist, once he has set forth his argument from moral choice.

The first type of determinism is the 100 per cent type, which maintains that under specifiable conditions a specifiable outcome will occur in all cases. For example, whenever a metal is heated (under ordinary conditions) it will expand. The second type of determinism is the statistical type, which maintains (roughly) that under specifiable conditions a certain result will occur but only in an explicitly stated percentage of cases. An instance of this is the statement that of all the people born in slums, 80 per cent will commit a crime at some time during their lifetime. The claim which I wish to make first is that if the moral argument of the indeterminist were valid against the 100 per cent type of determinism, it would also have relevance against the statistical type of determinism. This point is particularly important, since many indeterminists attempt to acknowledge the incontestable existence of an impressive measure of regularity in human behavior by emphasizing that they object on moral grounds only to the 100 per cent type of determinism and not to the statistical type.

To establish my case, let us suppose that, contrary to fact, we knew that all hunters are subject to the following 100 per cent deterministic law: All hunters commit homicide at some time after returning from jungle life. The indeterminist would say that if these hunters were really subject to such a causal law, they could not help becoming murderers and therefore we should have no right to punish them for their crimes. What would the position taken by the indeterminist have to be if we had a statistical type of law stating with near certainty that, of all the people born in slums, in the long run 80 per cent will commit a crime at some time during their lifetime? To be sure, this statistical law would not entitle us to say that any particular individual(s) born in the slums will become criminal; hence, it does not preclude the possibility that some particular person (or persons) be among the 20 per cent whose conduct is legal and that, to this extent, the person in question be regarded as having acted "freely" in the indeterminist sense. In so far as responsibility is an individual matter, it might even seem that our statistical law would permit the indeterminist to employ his own criteria for assigning individual responsibility to as many as 20 per cent of those persons originating in the slums. But if the 80 per cent who actually did commit a crime at some time during a long interval of time were simultaneously brought to trial before a judge holding the indeterminist point of view, the statistical law in question would deny him the logical right of making individual assignments of responsibility; this law would not enable the judge to designate among the culprits any one or any group of whom it could meaningfully be said that they "could" have avoided the crime by being among the 20 per cent who did, in fact, avoid it. For if a procedure for carrying out such a designation were possible — which it is not — the statistical law would remind us that not only all the remaining defendants arraigned before the judge but also some of those actually belonging to the 20 per cent *could then not have helped* violating the statutes. This means that if over a long period of time we select all those having originated in a slum and not guilty of any crime, the remainder having a similar origin will *always* as a matter of fact commit a crime and will constitute 80 per cent of those born in slums. Thus by the indeterminist's own criteria for assigning responsibility, the judge would not be able to carry out such an assignment individually as he must, because sufficient causality is assured by the statistical law to preclude his doing so consistently with indeterminist premises. If the indeterminist denies the justice of punishment, as he does in the case of 100 per cent determinism, he cannot assent to the punishment of individuals belonging to groups concerning which statistical laws make only a statistical prediction of conduct. Accordingly, the indeterminist must have moral objections to 100 per cent determinism and statistical determinism alike. This means that he must be a foe of the belief that any kind of scientific study of man is possible!

To establish the invalidity of the moral argument offered by the indeterminist, I shall now try to show that there is no incompatibility between the deterministic assumptions of scientific psychology on the one hand and the meaningful assignment of responsibility, the infliction of punishment, and the existence of feelings of remorse or guilt on the other.

CAUSALITY AND MORAL RESPONSIBILITY

The first point to be made clear is that determinism should never be identified with the prescientific and primitive doctrine of fatalism. The fatalist says that regardless of what we do, the outcome will be the same. By contrast, the determinist says that *if* we do such and such, *then* the effect will be thus and so. The fatalist thinks that if you go into combat, and if "some bullet has your name on it," you will be killed no matter what you do. Thus he would say that when a natural disaster occurs, it does not matter whether you are at the scene of the disaster or not; if you are not there but are "destined to die" that day, you will be destroyed some other way. The determinist maintains that a person will die on a certain day only if the conditions which lead to death materialize for that person on that day, as indeed they do at some time for each of us. Unlike fatalism, determinism allows causal efficacy to human actions.

The second point to keep in mind is that physical laws do not in any sense force bodies to behave in a certain way, but merely describe how, as a matter of fact, they do behave. Similarly, psychological laws do not force us to do or desire anything against our will. These laws merely state what, as a matter of fact, we do or desire under certain conditions. Thus if there were a psychological law enabling us to predict that under certain conditions a man will desire to commit a certain act, this law would not be making him act in a manner contrary to his own desires, for the desire would be his. It follows that neither the causes of our desires nor psychological laws, which state under what conditions our desires arise, compel us in any way to act in a manner contrary to our own will.

An illustration will show that district attorneys are determinists, since they assume in their work a definite causal connection between motives and acts. In a recent French film we find a district attorney married to a rather unsophisticated lady whom he had been suspecting of violating her marital vows. While speaking to her, he found a seemingly innocent way of mentioning the name of his rival. She promptly gulped, and then tried to maintain with studied innocence that she had had no motive at all for gulping. He insisted that she had had a very definite motive, and as it turned out he was right.

It should not be thought that the indeterminist is now prepared to surrender, for he has yet to use his strongest weapon. Says he: "We are all familiar with the fact that when we look back upon past conduct, we frequently feel very strongly that we could have done otherwise. If the determinist is right in saying that our behavior was unavoidably determined by earlier causes, this retrospective feeling of freedom either should not exist or else it is fraudulent. In either case, the burden of proof rests upon him." The determinist gladly accepts this challenge, and his reply is as follows: Let us carefully examine the content of the feeling that on a certain occasion we could have acted other than the way we did, in fact, act. What do we find? Does the feeling we have inform us that we could have acted otherwise *under exactly the same external and internal motivational conditions?* No, says the determinist, this feeling simply discloses that we were able to act in accord with our strongest desire at that time, and that we could indeed have acted otherwise if a different motive had prevailed at the time. Thus the determinist answer is that the content of this "consciousness of freedom" consists in our awareness that we were able to act in response to our strongest motive at the time[2] and that we were not "under compulsion" in that sense. But the determinist reminds us that our feeling of "freedom" does not disclose that, given the motives which acted on us at the time and given their relative strength and distribution, we could have acted differently from the way in which we did, in fact, act. Neither do we feel that we could have responded to the weaker of two contending motives, or acted without a cause or motive, or chosen the motives which acted upon us. Since the retrospective feeling of freedom that we have does not report any of these results, its deliverances contain no facts incompatible with the claim of the determinist (*8*, *11*, *7*, *4*).

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[2] The claim that we act in response to our strongest conscious or unconscious motive is not a covert tautology. Cf. (8), Ch. II.

The analysis we have offered is applicable at once to the case of remorse, regret, or guilt. We sometimes experience remorse over past conduct when we reconsider that conduct in the light of *different* motives. Once we bring a different set of motives to bear on a given situation, we may feel that a different decision is called for. If our motives do not change, we do not regret a past deed no matter how reprehensible it would otherwise appear. Regret is an expression of our emotion toward the disvalue and injustice which issued from our past conduct, as seen in the light of the new motives. The regret we experience can then act as a deterrent against the repetition of past behavior which issued in disvalue. If the determinist expresses regret concerning past misconduct, he is applying motives of self-improvement to himself but not indulging in retroactive self-castigation or blame. Retroactive blame is futile, since the past will never return again. Thus, by responsibility the determinist does not mean retroactive blameworthiness, but rather liability to reformative or educative punishment. Punishment is educative in the sense that when properly administered it institutes counter-causes to the repetition of injurious conduct. The determinist rejects as barbarous the primitive vengeful idea of retaliatory punishment. He fails to see how the damage done by the wrongdoer is remedied by the mere infliction of pain or sorrow on the culprit, unless such infliction of pain promises to act as a *causal* deterrent against the repetition of evil conduct. We recall that the indeterminist accused the determinist of cruelly punishing people who, if determinism is true, cannot help acting as they do. The determinist now turns the tables on his antagonist and accuses him of being gratuitously vengeful, on the grounds that the indeterminist is committed by his own theory to a retaliatory theory of punishment. The indeterminist cannot consistently expect to achieve anything better than retaliation by inflicting punishment; for were he to admit that punishment will causally influence all or some of the criminals, then he would be abandoning the basis of his entire argument against the determinist. We see that determinism does not entail the doctrine *tout comprendre, c'est tout pardonner*.

What does the determinist believe about the application of punishment? From his point of view, punishment should be administered to the person upon whom the decisive motive acted, for that person is the essential junction of causes, and it is he who is likely to cause harm again if unpunished. Thus the doctrine of the determinist does not commit him to punishing the parents or social environment of the culprit for the culprit's deeds, even though they are the basic cause of his misconduct. Such a procedure would be of no avail if the aim is to rehabilitate the wrongdoer. There are two types of cases, however, in which the determinist does not apply punishment. When a person is acting under compulsion, he is being prevented from implementing his own desires. In that event, his internal state is irrelevant to what he does. Since his internal state needs no reforming, punishment would be completely misplaced in such a case. Again, in the case of insane behavior the determinist does not apply punishment, since insane people provide no unified point for the application of a counter-motive. More specifically, their internal state is not responsive to the external influences of punishment, and therefore the infliction of punishment upon them cannot be counted on to change their future behavior in the desired direction. Once Ophelia had lost her mind, even Hamlet's words could have no effect on her, and similarly for Marguerite and Faust.

It is apparent that the entire problem of responsibility can be solved within the domain of deterministic assumptions. Thus the issue is not *whether* conduct is determined but rather *by what factors* it is determined, when responsibility is to be assigned (2). Far from facing insuperable difficulties with the problem of responsibility, the determinist and the scientific psychologist now challenge the indeterminist to provide a logical foundation for the penal system.

OTHER ARGUMENTS OF THE INDETERMINIST

It is sometimes said that, when applied to man, the deterministic doctrine becomes untenable by virtue of becoming self-contradictory. This contention is often stated as follows: "The determinist, by his own doctrine, must admit that his very acceptance of determinism was causally conditioned or determined. Since he could not help accepting it, he cannot argue that he has chosen a true doctrine." To justify this claim, it is first pointed out rightly that determinism implies a causal determination of its own acceptance by its defenders. Then it is further maintained, however, that since the determinist could not, by his own theory, help accepting determinism, he can have no confidence in its truth. Thus it is asserted that the determinist's acceptance of his own doctrine was forced upon him. I submit that this inference involves a radical fallacy. The proponent of this argument is gratuitously invoking the view that if our beliefs have causes, these causes *force* the beliefs in question upon us, against our better judgment, as it were. Nothing could be further from the truth. My belief that I am now looking at symbols on paper derives from the fact that their presence is causally inducing certain images on the retinas of my eyes, and that these images, in turn, cause me to infer that corresponding symbols are actually present before me. The reason why I do not suppose that I am now addressing a group of students in a classroom is that the images which the students would produce are not now in my visual field. The causal generation of a belief in no way detracts from its reliability. In fact, if a given belief were not produced in us by definite causes, we should have no reason to accept that belief as a correct description of the world, rather than some other belief arbitrarily selected. Far from making knowledge either adventitious or impossible, the deterministic theory about the origin of our beliefs alone provides the basis for thinking that our judgments of the world are or may be true. Knowing and judging are indeed causal processes in which the facts we judge are determining elements along with the cerebral mechanism employed in their interpretation. It follows that although the determinist's assent to his own doctrine is caused or determined, the truth of determinism is not jeopardized by this fact; if anything, it is made credible.

We have yet to consider the bearing of developments in atomic physics on this problem, since a number of writers have argued that these developments provide evidence for the indeterminist position.

It is known that for measurements in the domain of subatomic dimensions, the Heisenberg Uncertainty Relation comes into play. This relation states that for a given uncertainty or vagueness in the value of an observable quantity like position, there is a definite limit, imposed by the laws of nature, on the accuracy with which the simultaneous value of another empirical quantity like velocity can be known, and that this limit is independent of the particular apparatus or method used in the determination. Since the apparatus used in measurement disturbs the system under observation, it would seem that the possibilities for refining measurements are not unlimited and that the dream of classical physics can therefore never come true. No refinement of experimental technique could ascertain the present values of the observables of a physical system accurately enough to enable us to make a *precise* prediction of the future values. Consequently, the new quantum mechanics is content to specify the frequencies or probabilities with which different values will be found in a given set of measurements. These probability predictions are thus based on a statistico-determinism for the micro-processes of subatomic physics rather than upon the 100 per cent type of determinism which prevails in the physics of the macrocosm.

What are the implications of this situation for the controversy between the philosophical indeterminist and the scientific psychologist? In his *Atomic Theory and the Description of Nature*, Bohr gives several reasons for supposing that the most precise experimentally ascertainable knowledge of the momentary state of the constituent particles of the nervous system and of the external stimuli affecting it permits only a statistical prediction and not a completely detailed prediction of the fate of these stimuli in the nervous system. Nevertheless, there are important reasons why the philosophical indeterminist can derive no comfort from this situation. It has already been shown that if the moral argument for indeterminism is to be valid, statistico-determinism is objectionable along with 100 per cent determinism. For genuine free will would prevail only if the quantum theory were to conclude that all human acts (macrophenomena) can occur with the same frequency. But the theory does not make this assertion at all. The microscopic probabilities yielded by the theory are such that the acts which a macroscopic psychology would predict are overwhelmingly likely to occur. From the standpoint of the macrophenomena of human conduct a 100 per cent type of determinism holds, to all intents and purposes. As Cassirer has stated, the extent of the determination of human behavior is so great that the free will of the philosophical indeterminist can find no refuge in it (*1*). Schrödinger has aptly summarized these conclusions in the following words: "According to the evidence . . . the space-time events in the body of a living being which correspond to the activity of its mind, to its self-conscious or any other actions, are (considering also their complex structure and the accepted statistical explanation of physico-chemistry) if not strictly deterministic at any rate statistico-deterministic.

To the physicist I wish to emphasize that in my opinion, and contrary to the opinion upheld in some quarters, *quantum indeterminacy* plays no biologically relevant role in them, except perhaps . . . in such events as meiosis, natural and X-ray-induced mutation and so on . . . let me regard this as a fact, as I believe every unbiased biologist would, if there were not the well-known, unpleasant feeling about 'declaring oneself to be a pure mechanism'" (9).

CONCLUSION

In this paper an attempt has been made to show that the arguments advanced against the possibility of a scientific study of man are without foundation. Of course, the truth of either strict determinism or statistico-determinism has not been established conclusively; for this cannot be done by logical analysis alone, but requires actual success in the scientific search for uniformities. Since the important arguments against determinism which we have considered are without foundation, the psychologist need not be deterred in his quest and can confidently use the causal hypothesis as a regulative principle, undaunted by the *caveat* of the philosophical indeterminist.

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When Is Human Behavior Predetermined?

EDWIN G. BORING

Although the argument of man as a victim of absolute determinism versus man as a creature exercising complete freedom of action is a very old problem, Boring points out that recent world developments and the progress of psychology justify his re-examining the issue. He discusses this conflict of ideas in relation to the scientist's mission, to the emergence of great men in history, and to the values served by man's beliefs. Boring points out that although the two concepts of determinism and freedom appear to be objectionably incompatible, they are not mutually exclusive, and indeed they may both be true, although the two truths serve different purposes. Dr. Boring has indicated in correspondence that on logical grounds some psychologists disagree with his view that the two notions are incompatible, so do we have a problem here or do we not? Whether or not one agrees with the author, this is indeed a stimulating article on a really basic issue in psychology.

Dr. Boring is a distinguished writer, teacher, editor, and scientist. He is Edgar Pierce Professor of Psychology Emeritus at Harvard. The selection that follows was presented as the first Richard M. Elliott lecture in psychology at the University of Minnesota in 1956 and was published in *Scientific Monthly* of April, 1957 (pp. 189–196). It is reprinted by permission of the publisher and the author.

When is human behavior predetermined? Is man free to choose? sometimes? always? in respect of everything? May he thus by choice control his own individual destiny? This is surely what most men believe most of the time. The scientist, on the other hand — because the business of science is the study of causes and their effects — keeps insisting that any action of man, if we but knew enough, could be referred to its causes; that the explanation of all human behavior lies in the ancestral genes of the behaving person, in his past experience, and in the various accidents that have happened to him since he was conceived. On which side does truth lie? Is man quite free to think as he will or are his beliefs but a reflection of the climate of fact and opinion that envelops him, and of the circumstances that belong to the century, the country, and the family in which he lives?

This problem is not made easier when we realize that man's belief that he is free may itself be predetermined. The belief in freedom could be man's great delusion — nearly, if not quite, immutable. It is conceivable, you see, that there could be a society of talking robots, designed so that they continue to interact one with another in accordance with the principles on which they have been constructed, all of them chattering the while about their behavior in words that imply that each is free to choose whatever he does; that each, choosing freely, thus becomes responsible for his own conduct — a society of robots in which everyone asserts his own freedom for the excellent reason that he is *not* free to deny it.

We keep thinking, representatives of mankind that we are, that the integrity of each of us is so great that our assurances and convictions are at least partially self-validating; that our sense of certainty, even though it may waver, must at the very least tend to point toward truth. But what if delusion has been designed into us? What if the robot residents of some psychologist-designed utopia have been constructed so as to believe in falsehood and never to know it, the truth of their basic determinism being carefully hidden from them behind barriers of rationalizations to which assurance and conviction are firmly fastened? What are we to say in the face of this possibility? Biology offers us no protection against it, for there is always the possibility that survival can be favored by delusion, and that wisdom may on occasion be, if not lethal, at least not maximally helpful. In this respect man finds himself caught in an egocentric predicament, unable to grasp the standard by which he can tell reason from rationalization. What is he to do? What should we do?

This is no new problem, but it has recently received a new importance, because the development of the behavioral sciences has shown how the actions of animals and men can be controlled in greater degree than had formerly been possible, and even more, I should say, because the totalitarian countries, with their brain-washings and their forced self-accusations, have shown that man's integrity — the citadel of his freedom — can be invaded, and man's opinion, faith, and conscience enslaved. Indeed, the sense of freedom could be turning out to be man's great delusion. Is it? How do you answer a question like that?

There is, I believe, an answer, for that is what this paper is about; but first let us see how this dilemma between freedom and determinism keeps turning up as wise men try to understand and cope with human action.

FREEDOM AND DETERMINISM: THE DILEMMA

Just now the universities — all of them — are worrying about what will happen when the new birth-rate floods the admissions offices with would-be students. How can academe accommodate them all? This matter came up in a certain faculty of a large university some months ago, and the president expressed his concern and gave his advice on how to meet the coming tidal wave. "But why admit so many?" a professor of government asked. "Where," he added, "does the area of decision in this matter lie?" The president was able to discern no such idea. He knew that his university, an endowed institution, could still not remain unconcerned about the applicants it rejects. You might decide for new dormitories but not for a fixed enrollment. The professor, of course, was believing in freedom just then. That is the way governments work: they make decisions. And the two men, the president and the professor, were representing irreconcilable philosophies. Yet no one remarked that incompatibles cannot both be true, for this contradiction is so commonplace that people are fully accustomed to ignore it.

Years ago William McDougall, the psychologist, was my colleague at Harvard. He believed in freedom for the human mind — in at least a little residue of freedom — believed in it and hoped for as much as he could save from the inroads of scientific determinism (*1*). To the determinist-psychologists, such a view was scientifically immoral. John B. Watson, behaviorism's founder, reviewed McDougall's textbook of 1923 under the title "Professor McDougall returns to religion," and you may be sure that Watson was not thinking of himself as a rejoicing father welcoming back a prodigal (2). I used to wonder about McDougall and determinism, and then one afternoon in a colloquium — one of those rare occasions when argument brings insight and does not merely serve to harden preconceptions — I found out where lay the difference between us — McDougall, the voluntarist, and me, the determinist. McDougall's freedom was my variance. McDougall hoped that variance would always be found in specifying the laws of behavior, for there freedom might still persist. I hoped then — less wise than I think I am now (it was 31 years ago) — that science would keep pressing variance toward zero as a limit. At any rate this general fact emerges from this example: freedom, when you believe it is operating, always resides in an area of ignorance. If there is a known law, you do not have freedom.

Then there is Francis Hackett's assertion that psychoanalysis did not help the novelist after all (3). The novelists thought at first that Freud had presented them with accurate knowledge of human nature — a knowledge that psychology had hitherto failed to provide. Freud did, of course, but he also gave them determinism. Novelists, however, need heroes, and heroes need freedom. What machine was ever a hero to its owner unless the owner — a child undoubtedly — endowed it with freedom and life? You cannot write a novel about robots, unless they are free. The characters must meet difficulty and overcome it, in face of the possibility that they could have failed (4). It is the same with an athletic team. A team that won because it was drugged would not be given the trophy. Victory must originate from within the victor, not be rigged in advance.

The Russians — I am relying on Raymond Bauer's excellent historical account of the development of psychology in the Soviet Union — had occasion to discover this dilemma (5). In the 1920's they stuck to economic determinism as part of their dialectical materialism — to that and to Pavlov's determinism of conditioning. Then their 5-year plans got into difficulty and, in the early 1930's, the leaders reversed themselves, abandoning Pavlov, conditioning, mental testing, and everything that seemed to make the individual a consequence of causes outside himself. As a substitute they introduced a voluntaristic dynamic psychology, letting praise and blame, responsibility and guilt, operate instead of conditions external to the individual. The leaders themselves, of course, must still have believed in the predeterminism of behavior, for it was they who were to determine the conduct of the people by making them believe they were free and responsible. That the leaders thought they were free to delude the people into believing they were free is pretty obvious.

And then there is my colleague, B. F. Skinner, famous for his patterning of the lives of rats and pigeons and now turning his attention to the teaching of children in the grades (6) and to the analysis of psychotic behavior (7). He preaches a gospel of how psychological knowledge can be used to improve human living (8), and how, as behavioral science advances, human conduct becomes more and more subject to control (9). Control by whom, though? Or should one ask, by what? Skinner is saying something more than that behavior is caused, that it is the inevitable consequence of determinable scientific law. He is saying that, because behavior can be controlled, human living can be improved. Not merely that human living will be improved because biological selection promotes human weal willy-nilly, but that it can be and that there is therefore a possibility that it may not be, unless the gospel is accepted. This is sheer voluntarism. It is a mixing of languages, a hoping that hoping itself makes no sense except as a sign of the existence of a feeling of desire that contributes to the inevitable. Can one choose to do without choice?

It is in this way that the determinist gets trapped in the egocentric predicament (*10*). He has to be outside the system in order to recommend it. He would be more convincing if he would take up his stand firmly on the outside — the man from Mars viewing human society — and describe what is going on, that and nothing more, just as a human being may describe the behavior of ants, without praise or blame for their conduct, or suggestions for improving their social structure, or even the admonition that ants could be happier if they were controlled by positive reinforcement and not by aversive stimulation. A book by a behavioral determinist ought not so much advocate the control of behavior as describe it. Advocacy undermines the argument for determinism because preference belongs to the world of values. You can indeed consider advocacy as a behavioral event with necessary and sufficient antecedents and consequences, but such rigor requires that the author rid himself of preferences and prejudices in his devotion to objective description if his implications are not to subvert his explication.

TRUTH VERSUS POLICY IN SCIENTIFIC THEORY

Perhaps I have now already made my point. It is that fact and value, as surely everyone knows, belong in different worlds, each with its own language, and that the wise man must keep both in his repertoire if he is to get along in the culture in which he lives. To me this view means that the wise man is something more than the scientist, who does indeed need, as scientist, to stick to determinism and thus to description. I am saying that science must be something less than the one way to truth. But is not this exactly the principle that prevails today? In 1907, J. J. Thomson remarked that a scientific theory is a policy, not the truth but a view that, if held, gets us ahead — a view to be held as long as it does get us ahead (*11*). Today we hear less about theories and more about models. What is the difference? The theory claims to be true, even though we all know that assurance about the validity of these claims varies greatly from theory to theory and from time to time for the same theory. The theory is an *as*, whereas the model is an *as-if*. The theory is indicative; the model, subjunctive. The model is a pattern to be abandoned easily at the demand of progress. Thus science is less than the whole of wisdom, and the wise teacher of science, being also a human being, will not seek to try to make those other human beings who come under his tutelage less wise or less free than himself.

Now let us examine how this dilemma enters into another field and how it can be met there. Let us consider the great man.

GREAT MEN: FREEDOM AS A NEGATIVE CONCEPT

Long ago the problem of freedom and determinism as it pertains to the conduct of great men came up in the contrasting views of Carlyle and Tolstoy. Carlyle, writing about heroes in 1840, was for freedom (*12*). "The history of what man has accomplished in this world," he said, "is at bottom the History of the Great Men who have worked here." Progress is what the great men started. Little is ever said about what started them, for it is conventional to suppose that they are self-starters, creative minds, and it would be derogatory to refer to their causes, if indeed they have any.

Tolstoy — in his *War and Peace* (1869) — was, of course, on the other side (*13*). "A king is history's slave," he said. "History . . . the unconscious, general, hive-life of mankind, uses every moment of the life of kings as a tool for its own purposes. . . . The higher a man stands on the social ladder, the more people he is connected with and the more power he has over others, the more evident is the predestination and the inevitability of his every action." That is, in part, the *Zeitgeist* theory of history, before Matthew Arnold picked that word out of Goethe's writing and made it important. According to this view the great man becomes merely the agent of history. He is not only the cause of his consequences but also the consequence of his causes. You can regard him, if you wish, as a symptom, an event so conspicuous in an otherwise obscure causal train that it comes to be the sign or label by which the whole train is known — like calling all classical physics *Newtonian*.

Herbert Spencer was on the tough side of this argument with Tolstoy. William James was on the soft side with Carlyle. James was promoting scientific psychology in the days when it was very new, but also he was holding tight to the dignity of man. While he wanted us all to meet the new experimental psychologists "these new prism, pendulum, and chronograph-philosophers," as he called them, he also wished to save the human mind from destruction by "the spying and scrapping, the deadly tenacity and almost diabolic cunning" which the scientific attack in the hands of the meticulous German *Gelehrter* threatened to bring about — as James thought.

There is a proximate solution to this great-man problem, although one that does not go quite far enough. It is that you have freedom only when you are not interested in causal antecedents, in genesis. Everything depends on where you place the boundaries of your universe of discourse. If you are satisfied to consider only great men and their consequences, then of course they appear as free, because you have ignored all the conditions that made them great, the conditions that require the great scientist at the moment of discovery (when there is such a moment) to have the insight that puts him into the histories of science. So the great man is found free, freed by the unconcern of all hero-worshippers.

Now change your point of view, enlarge your universe of discourse, inquire into the antecedents of the great man's great achievement, find out that he was, at least to some degree, anticipated by others, that another man, a small one, independently made the same discovery later, without knowledge of what the great man had done, and then you begin to transform the great man into a symptom and to believe in the *Zeitgeist* as furnishing the climate necessary for great discovery. Thus you move over from Carlyle to Tolstoy, and from William James to Herbert Spencer. Although you have diminished the dignity of great men, you have, on the other hand, enlarged your vision of the causal web of the universe.

It is possible to visualize a model of this causal nexus. Imagine a diagram, plotted between time, which runs from left to right, and simultaneity, which is up and down. Fill it in with separate little circles, each of which is an event — an event like Max Wertheimer's thought on the train in 1910 about perceived movement's being *ipso facto* a phenomenon, the *phi*-phenomenon, the thought that made him get off at Frankfurt-am-Main, buy a stroboscope at the German equivalent of the dime store, and start, after a few billion other events, the school of *Gestalt* psychology (*14*). Now on this diagram draw in all the cause-and-effect relations from every event to its consequents at the right. Simultaneous events are above and below each other and are never connected directly. Multiple causes and multiple effects are, of course, the rule. Every event has many causes and many effects. Now select a crucial event, one of the circles, Wertheimer thinking of *phi* on the train. Put in a boundary line that excludes all the antecedents and includes all the consequents. There you have the model for freedom. Wertheimer is seen as an originator. His idea was *sui generis*. When you think of freedom, you think in these terms. But take away the boundary, and you have before you the entire causal nexus. Wertheimer's insight may now be a necessary link in the system, but there are many others. His insight becomes less special, but your universe of understanding is enormously increased.

The main point here is that freedom is a negative conception. It is the absence of causes. The freedom for which men fight and die is also a negative conception, the absence of constraints. Within science the complaint of the intuitionists about the positivists has been that positivism offers constraints upon scientific freedom; that positivism is a police measure insisting that explanation shall be in terms of *nothing but*, as the protesting intuitionists put it, whereas they, the antipositivists, want not exactly *something more*, for they are not prepared to specify the something more, but freedom to let the inquiring mind advance as it will. This is the faith of the artist who resists control or assessment until his job is done and judgment may be passed. Who shall say that artistic expression should be more rigorously constrained?

So the question is: When is *nothing* better than *something?* And the answer is: You can tell *ex post facto*, and freedom — a negative, a faith in a nothing — has justified itself in more contexts than one.

It is true that, in general, men do not like nothings. Scientists will hold on to a disproved theory for long years until there emerges a better theory to replace the wrong one. Belief abhors a vacuum. So, too, men will hypostatize a negative into a positive, as they have done with the concept of freedom and also with the concept of chance. Both *freedom* and *chance* are terms that are used when efficient causes of present events are not known and often appear to be unknowable.

The scientific view of the history of thought is, of course, the deterministic one. You look for causes and believe in their existence even when you cannot specify them. Tolstoy and Herbert Spencer, not Carlyle and William James. But the scientists' view is often quite different from the scientific view, for a scientist is a human being, required to make value judgments if he is to survive in the milieu in which he has to live. Indeed, there exists what might be called the moral history of science. It deals with the psychological forces that block or misdirect the progress of science and that also drive science forward: the inertias of the scientists, their prejudices, their egoisms, their needs for self-consistency, and also the positives of these negatives — the integrity, the pride, the loyalty of scientists. You might regard these personal characteristics as determining causes which advance or hinder progress, and then you would still be thinking scientifically; but actually this is not the way the business of science runs.

Take enthusiasm, for example. Science runs on enthusiasm, gets its research done by dedicated workers; yet enthusiasm is a prejudice, and science is supposed to eschew prejudice. There is a very real conflict here between objectivity and personal drive, a conflict that has the consequence that you ought not to trust the ego-involved theorist, or at least you ought not to be influenced by the intensity of his conviction. His enthusiasm has pushed the pendulum one way, and a better approximation to fact is reserved for posterity, which will have all the evidence before it and none of the distorting enthusiasms (*15*). Max Planck said that many a wrong theory could not be abandoned until its author died (*16*).

So what? You can be too scientific to be successful as a scientist. You need your prejudices. Trust posterity to straighten you out, and posterity's posterity to do even a better job.

This is a psychological antinomy. The scientist's mind must make use of incompatible attitudes. He will have to use now one attitude, now the other. Or the necessary combination of incompatibles may be found in a set of men, or perhaps merely in a pair, say, the enthusiastic researcher and the sober handbook-writer. The basic fact remains, however: the prejudiced mind gets more progress into science than does the mind of the critical assessor.

CAUSES OF BELIEF

In this connection it becomes desirable to inquire into the nature of belief, to ask what use are an organism's beliefs to it, and when, if ever, it is a good thing to believe in error. When is man advantaged by having a great delusion?

There is no need for us to try to distinguish between a belief and a pattern of behavior. The termite believes in a totalitarian society. The life of each termite is devoted to the fulfillment of its role in a complex social organization, which the ethnologist, William Morton Wheeler, once compared favorably to the less efficient, more variable, less assured governance under which man survives (*17*). The newly hatched gosling follows its mother, real or foster, or rather whatever large, dominating animal or other mobile object has come in those early hours of its life to bear the mother-image for it. Lorenz calls this fixation *imprinting* (*18*). It is the gosling's fifth commandment: Honor thy mother and follow her whither she shall go, that thy days may be long — for it is plain that a good belief has survival value.

Those beliefs survive that help the organism to survive: The termite; the gosling; the spider's web; the lioness springing for the throat of her quarry; man's gregariousness. Nor does a belief have to be in the genes. Man's social institutions persist because they are useful to him: forms of government; forms of religion.

Darwin's first principle also applies to these beliefs (*19*). Harmless but no longer useful remnants of originally useful beliefs survive: the cat circling around before it lies down on the parlor rug, as if treading down its bed in the forest; man, baring his second canine in a sneer, though he will not really bite. With man these remnants of useful habits may, however, gain a secondary use as they become means of communication. Your sneer warns the other fellow that you are ready to attack with teeth other than your biological ones.

Generalization may, moreover, preserve a belief that is actually harmful but not distinguished from the useful beliefs with which it is classed. The classical example is the sweet-tasting poison. But what about appetite? The belief in the goodness of eating is basic to the preservation of life, but it can also induce obesity. America is filled with people today who would be better off with a different adjustment of this habit. In a way the fat man's hunger is his great delusion, for he does not need so much food; and man's belief in his own freedom might turn out to be a similar kind of self-deception. It is doubtful that it would be sensible for a termite to believe in personal freedom. For it the good life is fixed by the state.

These human beliefs are, of course, very complex. For instance, is it ever good for man to believe a superstition? Probably yes, but let us consider ritual. Members of a Jewish family keep a kosher kitchen, not because they believe that any biological harm would follow if the two sets of dishes got mixed, but because they like to preserve ancient customs, to have their children perpetually reminded that they belong to a special group which has these customs. Patriotism is similar. The salute to the flag is good because it is symbiotically reinforcing. It makes you one with your compatriots. Both of these kinds of behavior are examples of good false beliefs — that is to say, false in their manifest content, yet good to have because of the psychological effect of having them.

Certainly the belief in human freedom of action is in one sense a superstition, one that is, however, justified biologically by the fact that it is woven into the fine structure of society. Language itself would have to be eviscerated were this conception to be extirpated from it. Beliefs, you see, can be false as to logical content and good as to use and function. Does not this conclusion settle the problem of freedom? It is a useful superstition.

But no, it does not, for the argument can also be made that causality is another useful superstition. This is what a scientific model is, a useful superstition, for it stands above the observed evidence. So we had better return to our principal inquiry.

CAUSALITY AS A MODEL

Against this background I now have three things to say.

1. The behavioral determinist is not wrong. We do indeed want all the controls for human nature that we can get. To prefer ignorance to knowledge is not best — not in the Western culture of this modern age.

2. The model of human nature in social interaction, which is the natural outcome of scientific thinking about behavior, is nevertheless only a model. It is something to have in your repertoire of usable models, something to use on proper occasions. It is pushing science too far to say that this model is true now, but a model does not have to be true to be useful.

3. The analogy that once recommended this model as something that might be true is classical physics, but physics has changed. Causality is not so simple a relation as it seemed to be to LaPlace and to Helmholtz. Physics has become psychological. Operationism says that what you cannot observe does not exist. If you cannot ever observe the position and momentum of an electron simultaneously, then they do not exist simultaneously. Here we are dealing with physical incompatibility, with the physical techniques of observation. In the case we are considering, however, we have only a psychological incompatibility, two attitudes that cannot be assumed simultaneously. The point is that behavioral scientists should not be coerced into too great a simplicity by physical analogy, when physics itself has had to revise its thinking so radically.

SHOULD BEHAVIOR BE CONTROLLED?

Sometimes the humanists raise the question, not whether behavior can be controlled but whether it should be (*20*). It is hard for me to take this question seriously. You need all the knowledge of control that you can have. Only then are you prepared to consider how it should be used.

Education and government are instituted for the purpose of human control, and nearly all discussion and debate of any subject are directed at control. I prepare this paper in the hope that by it I may exercise some small degree of thought-control upon all who read it. Skinner claims to have better and surer methods for the design of behavior than have been available heretofore. You should see his pigeons, taught to earn their livings by the rewarding of their successes (not by punishment of their failures). So it is that he envisages a happy society, in which success and reward are the rule, and frustration has been reduced or eliminated by good social design. No one, of course, ever designs frustration into a machine so that it tries to make the same wheel go in opposite directions at the same moment.

One objection made to the behavioral scientists' development of human control is that their power might get into the hands of evil men. This objection seems to me to miss the point. Surely any elite that undertook to use behavioral science to enslave the world would find beneficence more efficient than maleficence. Slavery would be designed as a happy and desirable state, and, if these successful slaves still felt that they needed variety in their companionship, variety can be designed too. All you need is the specifications for n personalities, and the desirable frequency for each of them, to get mass production going.

In any case, you should push knowledge of the means of social control as far as you can. Modern civilization would rather run the risk of being bombed out of existence than return to the complacency of the Middle Ages, when scientific inquiry into natural law was not one of the most important activities of wise men. It is true that the physicists opened a Pandora's box, but what wise man would have stayed them, would have counseled that more safety is to be found in ignorance than in knowledge?

As man alters the world in which he lives, he has to trust that he will be able to adjust it to himself or else adjust himself to it. So far the advance of civilization has consisted of these changes and adjustments, and I see no reason to fear that the behavioral determinists are starting something that will get out of hand. The attempt to control men's actions and thoughts is as old as history. You cannot have social engineering that does not conscript the individual.

USE OF INCOMPATIBLES

So we come back to the main problem. Do we have to accept incompatibles simultaneously? Perhaps not simultaneously, but certainly alternatively — or so it seems to me. Certainly we all like to believe that nature is uniform and does not admit contradictions. Nevertheless, it seems clear that there may be limits to the resolving power of the understanding mind. Let me remind you of four such instances.

1. First there are the *antinomies* of Immanuel Kant (*21*). The best known is that you cannot conceive of space as finite nor yet as infinite. What do you do? You admit the contradiction as a limitation of the understanding, and the practical man uses one model or the other as suits his thought. Kant also included freedom and determinism among the antinomies (*22*).

2. Then there is Ralph Barton Perry's *egocentric predicament*, the dilemma that applies especially to our argument (*10*). How can the mind that considers other minds include itself? If I am to see all other men as robots, can this seeing be an event in my own robotic nature or have I got to stay outside the system in order to discuss it? Human nature could be viewed whole by the man from Mars. If n is the population of the world, then at most you could never knowingly have more than n–I robots, for there has to be the 1 left over to do the viewing. In this way one can get around the difficulty of solipsism, not by reducing all reality to events in the Red King's dream, but by ruling the Red King out of consideration. And this was the reason for Max Meyer's writing a psychology under the title *The Psychology of the Other One* (*23*). Everyone counted but Meyer; he wrote the book.

3. Then there are Sir Arthur Eddington's *Postulates of Impotence*, the a priori impossibilities (*24*). The best known is the principle that you cannot detect a uniform translatory motion that is possessed by a system as a whole by means of observations taking place wholly within the system. This is a relativity principle, but it is also a kind of robotic egocentric predicament.

4. And finally there is Bohr's *Principle of Complementarity*, which includes the Heisenberg *Principle of Uncertainty*, that you cannot know both the position and momentum of an electron for the same instant (*25*). This seems to be a physical, not a psychological, incompatibility, but Robert Oppenheimer has told us that Bohr came upon this idea long before he ever formulated it, by thinking about such antinomies as fact and value, the tolerance of pure description as opposed to the intolerance of moral judgment (*26*).

So we do not have to be afraid of embracing incompatibles. It happens every day. Thought is polygamous. As a matter of fact, this kind of polygamy has been enormously eased by the present-day tendency to substitute the model for the theory. The theory had truth-value. It was a claim upon truth, and it had no right to persist — in spite of the fact that habitually it did — in the face of any single contradictory fact. As I have suggested, the theory is an *as*, whereas the model is but an *as-if*. You can have as many models as you want and use them when you will.

Causal determinism is the scientific model. It works enormously well. There are places in science where it breaks down, but they are not many. On the other hand, there are, in the process of living, all the situations in which values are called for and in which the scientific model itself fails. In such cases we get along best with the truncated causality model which we call freedom.

REITERATION

And that is that. Now that I am done I seem, to myself, to have said very little. Yet when I see the humanist battling the scientific behaviorist, seeking to save human freedom and dignity from the ruthless hands of the invading scientist, I feel that something should be said, and this has been it.

Human dignity is all right. It is not silly to want to save it. Robots do not have it. Science does not preserve it. It is an attribute that lies outside of science. It implies that its possessor is free. Freedom is a negative concept, a truncated causality, but it is part of the warp of language. To get rid of this concept would change the whole of our civilization. Yet we need not attempt that, for causality is only the form of a model, and freedom is also a model, and we can use our models at will without letting them dominate us.

One thing more — my parting shot. Do you want to know where to find a free man, a man who acts as if he were free and thinks of himself as free (and how much freer could he be than that)? Go to him who is earnestly trying to persuade you that all men are robots. He will not claim that his ardor was designed into him and has no necessary connection with the validity of what he is saying. If he calls himself a robot, still he will not act like one, for it takes a free man to start a war on freedom. An IBM machine does not have the dignity to make an argument convincing, and an IBMpty organism is a poor evangelist.

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Implications of Recent Advances in Prediction and Control of Behavior

CARL R. ROGERS

Having established with considerable assurance the causal antecedents of behavior (the determiners), psychologists find themselves in a position to influence, or even control, behavior. Since few behaviors are dominated by one and only one antecedent, but instead are resultants of many causes, then one should think of control as a relative matter. Dr. Rogers says that psychology has become an "if-then" science, and he devotes his attention to a brief description of thirteen behavior areas where he feels we can make a creditable showing in predicting the "then" when given the "ifs." He points out that the ability to predict human behavior is established, but that the real contribution of psychology to society depends upon how this knowledge is utilized. Knowledge of how to control human behavior is a power to be approached with thoughtful consideration of human values.

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The science of psychology, in spite of its immaturities and its brashness, has advanced mightily in recent decades. From a concern with observation and measurement, it has moved toward becoming an "if-then" science. By this I mean it has become more concerned with the discernment and discovery of lawful relationships such as that *if* certain conditions exist, *then* certain behaviors will predictably follow.

I believe that few people are aware of the breadth, depth, and extent of the advances in psychology and the behavioral sciences, and still fewer seem to be aware of the profound social, political, economic, ethical, philosophical, and educational problems posed by these advances. In this discussion I should like to focus on the educational implications of these advances in the science of psychology (which inevitably will involve me in some concern with the philosophical implications as well) and to review a few selected examples of what I mean by the increased ability of psychology to understand and predict or control behavior. Each illustration I will give is supported by reasonably rigorous and adequate research, though like all scientific findings, each is open to modification or correction through more exact or imaginative future studies.

What, then, are some of the behaviors or learnings for which we now know how to supply the antecedent conditions?

We know how to set up the conditions under which many members of a group will report judgments which are contrary to the evidence of their senses. They will, for example, report that Figure A covers a larger area than Figure B, when the evidence of their senses *plainly* indicates that the reverse is true. Experiments by Asch (2), later refined and improved by Crutchfield (7), show that when a person is led to believe that everyone else in the group sees B as larger than A, then he has a strong tendency to go along with this judgment, and in many instances does so with a real belief in his false report.

We know a great deal about how to establish conditions which will influence consumer re-

sponses and/or public opinion. I refer you to the advertisements in any magazine, or to the TV program, "The $64,000 Question," and the sales of the sponsor's lipsticks.

We know how to influence the buying behavior of individuals by setting up conditions which provide satisfaction for needs of which they are unconscious, but which we have been able to determine. It has been shown that some women who do not buy instant coffee because of "a dislike for its flavor" actually dislike it at a subconscious level because it is associated in their minds with laziness, spendthrift qualities, and being a poor housekeeper (*12*). This type of study has led to sales campaigns based upon appealing to the unconscious motives of the individual — his unknown sexual, aggressive, or dependent desires.

We know how to predict which members of an organization will be troublesome and delinquent. On the basis of a paper and pencil test, Gough (*11*) has predicted which department store employees will be unreliable and dishonest or otherwise difficult. He freely states that it is quite possible to identify, with a good deal of accuracy, the potential troublemakers of any organized group.

This ability to identify troublemakers is only an extension of the knowledge we have about prediction in other fields — predicting which individual is most likely to become a good salesman, or typesetter, or physician, or student in college.

We know how to provide conditions in a work group, whether in industry or in education, which will be followed by increased productivity, originality, and morale. Conversely we know how to provide the conditions which lead to low productivity and low morale. Studies by Coch and French (*5*), and by Katz, Maccoby, and Morse (*13*) show in general that when workers in industry participate in planning and decisions, and when they are not supervised in a suspicious or authoritarian way, production and morale increase. The reverse conditions produce a reverse effect. A study reported by Corey (*6*) indicates that when the leader of a teacher group acts in a manner which is understanding, and which facilitates participation, the group is more productive in making and carrying through plans.

We know how to provide the conditions of leadership which will be followed by personality growth in the members of the group, as well as by increased productivity and improved group spirit. Richard (*14*), in his experience as manager of an industrial plant, and Gordon (*10*), in his study of leadership of a workshop, have shown that where the leader or leaders hold the attitudes customarily thought of as therapeutic, the results are good. In other words, if the leader is understanding, acceptant, and permissive toward his group and also acceptant of his own feelings in the situation, then the members of the group show evidence of personality growth and function more effectively and with better spirit.

We know how to provide the psychological conditions in the classroom which will result not only in the usual learning of academic content, but in improved personal adjustment as well. Studies by Asch (*1*) and Faw (*8*) show that if the attitudes of the teacher are similar to those described above for the leader, and hence responsible participation by the student is permitted and encouraged, then academic learning proceeds about as usual as measured by conventional tests, and personal growth and adjustment improve significantly.

We know how to provide an interpersonal relationship with qualities such that it enables the individual to meet stress with more serenity, less anxiety. Thetford (*19*), in an experiment with group therapy, and Faw (*9*), in a recent study of teacher-pupil relationships in the classroom, came to similar conclusions, though using very different methods and instruments. When individuals — clients or students — have experienced for a time a relationship of warmth, understanding, and acceptance, they are able to meet stress situations with less physiological upset and quicker recovery of physiological balance [Thetford] and are less upset psychologically by the stress [Faw].

We know the attitudes which, if provided by a counselor or a therapist, will be predictably followed by certain constructive personality and behavior changes in the client. Studies which in recent years have been completed in the field of psychotherapy justify this statement (*17, 15, 16*). The findings from these studies may be very briefly summarized in the following terms:

If the therapist provides a relationship in which he is (*a*) genuine, internally consistent; (*b*) acceptant, prizing the client as a person of worth; (*c*) empathically understanding of the client's private world; then the client becomes (*a*) more realistic in his self-perceptions; (*b*) more confident and self-directing; (*c*) more positively valued by himself; (*d*) less likely to repress elements of his experience; (*e*) more mature, socialized, and adaptive in his behavior; (*f*) more like the healthy, integrated, well-functioning person in his personality structure.

It is obvious that the essence of these findings in the field of therapy is closely related to the three previous illustrations.

We now know how, I believe, to disintegrate a man's personality structure, dissolving his self-confidence, destroying the concept he has of himself, and making him completely dependent upon another. This example has not been, so far as I know, verified by objective research. I make this statement after having studied, as far as one is able, the methods used in preparing prisoners for confession in various purge trials in Russia, and the brain-washing procedures applied in Communist China. It seems rather evident that these methods use many of the principles of psychotherapy, but use them in reverse fashion to bring about the disintegration of the autonomous personality, rather than integration. In a curious and abhorrent way this tends to validate the principles of psychotherapy mentioned above, because it indicates that the lawfulness of the process of therapy may be used to build or destroy personality.

We know how to provide psychological conditions which will produce vivid hallucinations and other abnormal reactions in the thoroughly normal individual in the waking state. This knowledge came about as the unexpected by-product of research at McGill University (*4*). It was discovered that if all channels of sensory stimulation are cut off or muffled, abnormal reactions follow. If healthy subjects lie relatively motionless, to reduce kinaesthetic stimuli, with eyes shielded by translucent goggles which do not permit perception, with hearing largely stifled by foam-rubber pillows as well as by being in a quiet cubicle, and with tactile sensations reduced by cuffs over the hands, then hallucinations and ideation bearing some resemblance to that of the psychotic occur within forty-eight hours in many of these subjects. What the results would be if the sensory stifling were continued longer is not known.

We know how to influence psychological moods, attitudes, and behaviors through drugs. For this illustration we have stepped over into the rapidly developing borderline area between chemistry and psychology. From "truth serum," to the chemotherapy now practiced in psychiatric wards, to drugs for the normal citizen there are many ways of changing psychological states. We may take a drug to mobilize our energy to cram for an exam, or a drug to allay our anxiety about the exam. Drugs have reportedly been given to soldiers before a battle to eliminate fear. While much is still unknown in this field, Dr. Skinner of Harvard states that "In the not-too-distant future, the motivational and emotional conditions of normal life will probably be maintained in any desired state through the use of drugs" (*18*).

We know the psychological conditions of family life which, if established in a home, will tend to produce emotionally secure children with many socially valuable characteristics. Here we go to a very different field, that of personality development in children, for our example. We can measure the attitudes and emotional climate which parents are creating for their children, and from these measurements we can predict that Home A will in all probability produce children who will grow somewhat brighter over the years, will be emotionally secure, original, relatively unexcitable; who will be liked by their peers, likely to be leaders, and well-adjusted to adults. On the other hand we can predict that Home B will be likely to produce emotional, excitable children, with little emotional control, and with less of originality than the children from Home A. The studies done by Baldwin and others (*3*) at the Fels Research Institute are the basis for these statements. Home A is the home in which the parents' attitudes and behaviors cluster in what the investigators have termed the "democratic" category, and parental attitudes and behaviors in Home B cluster in what they term the "actively rejectant" group.

My purpose in the above examples has been to point up the wide-ranging power, the very diverse potentialities for control and prediction, which psychological knowledge is giving us. When we project ourselves into the future, and try to imagine the further developments which will inevitably come, the prospect arouses uneasiness. Small wonder that Dr. Robert Oppenheimer, in speaking of the points of similarity between his own profession, physics, and the profession of psychology, says that one of these points "is the extent to which our progress will create profound problems of decision in the public domain. The physicists have been quite noisy about their contributions in the last decade.

The time may well come — as psychology acquires a sound objective corpus of knowledge about human behavior and feeling — when the powers of control thus made available will pose far graver problems than any the physicists have posed." [1]

Inherent in this development of the psychological or behavioral sciences are, I believe, two profound questions for educators. They are: How do educators propose to use these rapidly increasing potentialities for influencing and altering human learning and human behavior? How shall we prepare students to live in a world where the possibilities for such control of human behavior exist?

I shall not attempt to answer either of these questions, but shall only comment on each one. As to how educators propose to use this accumulating knowledge, I believe it is clear that it will depend entirely on their philosophy of education, as that philosophy is operationally defined in action. We are rapidly acquiring the knowledge and the skills which will enable us to turn out passive followers or independent citizens. Many teachers and educators, if we take account of their actions rather than their words, have the former as their goal. They will be able to implement this purpose much more adequately in the future. On the other hand, if the aim is to turn out self-directing, inquiring minds which will form their own judgments as to the truth, then knowledge exists which can facilitate this purpose also. It will be up to the educators, and even more broadly, up to the community, to choose the direction in which we shall go.

With regard to how we shall prepare students to live in this fearsome future world, I believe some of the research I have cited suggests possible answers.

In the investigation by Crutchfield (7), it was found that about one-third of the responses made by a group of individuals were strongly influenced by the majority opinion, even when that majority opinion was clearly false. However, not all individuals were equally influenced. Some persons were swayed on almost every item by what they thought to be a solid group opinion, but others were influenced scarcely at all. They "called the shots as they saw them," regardless of what others might think.

When Crutchfield analyzed the personality characteristics of these two groups on the basis of extensive personality assessment, the differences were sharp. The conforming group, who were swayed by the majority opinion, tended to be individuals who had little understanding of themselves, were defensive, had to put up a good "front." They were rigid, moralistic, and had great respect for authority. They were somewhat anxious, guilty, suggestible, and unable to tolerate ambiguity. They lacked self-confidence, were vacillating, and tended to become confused under stress.

The independent group, on the other hand, were active, effective, persuasive leaders. They were individuals in whom others felt confidence, and they had confidence in themselves. They were natural, unaffected, non-defensive, and expressive. They were unconventional and adventurous.

To generalize somewhat speculatively from Crutchfield's study to some of the others, I believe it may be tentatively said that the individuals who may be most easily "managed" through the psychological know-how I have tried to sketch in this paper are those who are passive, rigid, insecure, and authoritarian. On the other hand, those who resist being "managed," who are able to deal intelligently with these possible influences, are confident, open, secure, independent, and spontaneous.

But here again we face an exciting fact. The individuals who were not overwhelmed by the majority opinion in Crutchfield's experiment bear a very strong resemblance to individuals produced in a democratic home atmosphere, to workers who have developed in a group-centered industrial situation, to students who have been exposed to an acceptant teacher-pupil relationship, to clients who have experienced a warm and empathic relationship in therapy. In other words, we already know to a considerable degree how to provide the conditions in which such individuals develop. And though the reverse evidence is not quite so clear, I believe it may be said that in large measure we also know how to provide the conditions in which the passive, insecure followers develop.

What I have been trying to say is that the growing body of knowledge in the behavioral sciences gives to our modern culture an astonishing power of choice. We know how to influence and mold behavior and personality in a great many significant ways. We also have available the choice of whether to set the conditions which develop a suggestible, submissive, unsure individual who can be easily influenced to behave in any way that "we" think wise, or the conditions which will develop an open, adaptive, independent, free-thinking, self-respecting individual. It is this latter person who will perhaps be able to use with intelligence and sensitivity to human values the enormous powers which the physical and behavioral sciences are putting at his disposal. The issue of what choice to make in this regard constitutes, I believe, the challenge of tomorrow both for education and for our whole culture.

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[1] From a speech to the American Psychological Association, San Francisco, September 5, 1955.

It might well be pointed out that with few exceptions the psychological know-how which I have sketched has not been widely used or exploited by society. Hence it might seem that the challenge as I have described it is greatly exaggerated.

It is quite true that this knowledge has not been widely used. In this respect the status of the physical sciences is very different from that of the behavioral sciences. The physical sciences have become so greatly respected that if scientists from these fields report that they can create a satellite in space, the only question in the public mind is, How soon will it be done? There is no tendency to scoff at the possibility, as the public in 1906 scoffed at the Wright brothers' "ridiculous" predictions that a machine could fly. As of 1955 the behavioral sciences occupy, in the public mind, a status similar to that of the physical sciences in 1906. The community does not as yet believe that the behavioral sciences can achieve results. Yet this attitude is changing with remarkable rapidity. Who would have supposed, a few years ago, that our military forces would invest millions of dollars in research in the behavioral sciences, that industrial leaders would employ consultants whose main task is to provide a therapeutic relationship for the executives, that research in consumer attitudes would be a big business?

So I conclude that knowledge in the science of psychology will in the near future be used and exploited as fully as knowledge in the physical sciences is used today. The challenge for educators is unreal only if we are looking a year or two ahead. From the long view I know of no problem holding greater potentiality of growth and of destruction than the question of how to live with the increasing power the behavioral sciences will place in our hands and the hands of our children.

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The Psychologist's Services in Solving Daily Problems

ERNEST HAVEMANN

Some areas in which control has been successful are of economic value to society. Objective assessment of human abilities has long been of major interest to psychologists, and more recently they have turned their attention to the problems of worker efficiency and machinery design — with marked success. Consumer behavior and its prediction is growing rapidly in both development of techniques and social acceptance. Havemann cites some well-known (but not most recent) examples of achievements in these areas. So-called motivational research must be recognized as controversial as an example of applied psychology, and the typical psychologist is more acutely aware of the ethical problems involved in control than one would suppose from the account here.

Mr. Havemann is a professional journalist, as mentioned in selection 7. The portion of his series of articles on psychology which appears below was published in *Life* Magazine of January 21, 1957 (pp. 84–102) and also in his book, *The Age of Psychology*, © 1957, by Ernest Havemann. Reprinted by permission of Simon and Schuster, Inc.

When psychologists were developing their basic principles through laboratory experiments in perception and learning, they never suspected how popular they were about to become. Certainly they never expected to be embraced by the business world. The old-fashioned businessman, after all, had strong notions of his own about humanity. To hire a man, who needed anything more than common sense? Any businessman could look at an applicant, talk to him and tell right away if he was a good worker. Training? You simply put him under a good tough foreman and if he had the stuff he would learn the job; if not you fired him. Hours? The longer the better; anybody knows you can do more work in 60 hours than 50. Morale? There's nothing that a raise won't cure.

It all made good common sense. But when a few pioneer psychologists left the classroom a generation or so ago to study these truisms, they turned out to be mostly untrue. One famous early experiment, conducted in 1916, was directed at learning how well a group of businessmen could judge job applicants in the traditional face-to-face meeting. The interviewers were 23 experienced men, mostly sales managers who hired salesmen all the time. Each of them individually talked to and rated the same 24 applicants. The results were almost as helter-skelter as if the names had been written on sheets of paper and churned up by an electric fan. No single applicant was ranked first by more than three of the 23 interviewers. One man was ranked first by one interviewer — but 16th, 19th and 22nd by others.

A sociologist, first cousin to the psychologists, tried another experiment and pretty well found out what is wrong with the interview method. He assigned 12 people to interview 2,000 homeless men and try to find out what had put them on the skids. Among the interviewers were an ardent Prohibitionist and a confirmed Socialist. The Prohibitionist found that the chief cause of the men's downfall was drink. The Socialist found that the chief cause was capitalism. The moral was that no interviewer can really see beyond the end of his own prejudices.

Out of such experiments has been born the subscience called industrial psychology, which more modern businessmen are heeding all the time. Indeed the application of laboratory knowledge to practical problems, in business and elsewhere, is rapidly becoming the psychologist's chief occupation. A few decades ago psychology's leaders were wondering where jobs could be found for all the students who had become interested in the subject. Now their worry is quite the opposite. With so many young psychologists streaming off the campus to take well-paid work in industry or government, the problem is whether the science is being frozen at too low a level of knowledge for lack of sufficient people doing pure research.

Perhaps the best-known application of psychology in our daily lives is the test — not just the intelligence test described in the previous article of this series, but the test for practically everything the human body can perform or the mind conceive. There are individual tests and group tests, written tests and oral tests; many are of proven value and some may turn out to be utterly absurd. There are tests for physical skills like manual dexterity and finger dexterity, for such talents as mechanical aptitude and musical aptitude, for personality traits like introversion, extroversion, masculinity and femininity. The manufacture, printing, sale and administration of tests is a multimillion-dollar business. Business firms use them to select the people they will hire and the people who will get promotions. The military services use them to decide which men will become aircraft pilots, radar operators, mechanics or typist-clerks. Colleges and private consulting firms use them to tell young people which careers to attempt.

HOW THE TESTS ARE TESTED

Test scores are graded and calibrated according to the techniques of psychological statistics, an adaption of some of the mathematician's tools. The person who takes them is usually ranked on what is called a percentile scale — a score of 75 meaning that he is better than 74.9% of those who have taken the test but not so good as the other 25%, a score of 50 meaning that he stands in the middle, and a score of one putting him at the very bottom. This has led some critics to deplore psychological tests as an attempt to reduce all human affairs to a bleak and mechanical rating system. Others have called the tests an unwarranted intrusion on private lives. But actually even the old-fashioned interview was a test of a kind in which the applicant had to live up to the interviewer's notions of how an applicant should talk. So was the trial period which used to be a standard practice. The only thing different about the psychological tests is that they attempt to establish ratings in an accurate and scientific fashion.

A study of people who had selected their careers on the basis of psychologically sound vocational guidance, based mainly on tests, once showed that 28 had succeeded for every one person who failed. For a similar group not given guidance, the ratio of success to failure was only 50-50. The Army's results are perhaps even more spectacular. It first gives a general intelligence test to its recruits, and the lowest 10% are immediately eliminated as untrainable. It then gives tests for aptitude in radio code, maintenance work, technical jobs, combat and other military tasks. By gearing actual training and assignment to these tests the Army finds it can take the average recruit and get as much efficiency from him as if he had scored 20 percentage points higher in the intelligence test. Thus many of the psychological tests have been proved successful. Unfortunately, the process has become such a fad that a good many phony tests have managed to sneak in undetected; many of those now in general use are about as useful, in the words of one psychologist, "as a rubber yardstick."

The creation of a good, accurate, reliable test of any human ability is an extremely lengthy and difficult process. Suppose, for example, that one is seeking a test for truck drivers, as the Army actually did over a five-year period. The first thing is to evaluate the standard state drivers' license tests, which most recruits have already passed. (Usually these tests prove very little except that the applicant is breathing and not blind.) The next thing is to try to discover what makes a good truck driver — how the good ones differ from the bad ones in physical characteristics, temperaments, reaction time and various types of knowledge, dexterity and skill, as well as in many matters of personal life and habit. Once it is decided what characteristics seem to make a good truck driver, the test then has to be designed to try to measure these things. Finally it must be administered to thousands of people to find out what constitutes a good or a bad score, and these people have to be followed up to see if the test actually separates the successes from the failures. All this takes a lot of time and money, which have to be invested without guarantee of success. After much work Army psychologists finally came up with a test for truck drivers which seems to be pretty accurate — but they might just as easily have failed.

SCIENCE — OR JUST ONE MAN'S OPINION?

A lot of jerry-built psychological tests in wide use today have never themselves been tested — or as the psychologist says "validated" — in this careful fashion. They represent only one man's opinion of what a good test might be and have no more actual scientific value than did the old-fashioned businessman's snap judgment based on common sense. In this class fall most of the tests used by some companies for the selection of executives. Since nobody has ever proved scientifically what it is that makes a good executive — and since the qualities expected of an executive vary widely from industry to industry and company to company — how can anybody expect to draw up a test?

Even the good tests, moreover, are frequently misused. Some company presidents and personnel men have become so intrigued by the idea of spotting the brightest people in a group of applicants with a 20-minute intelligence test that they have made grievous mistakes. They have assigned extremely quick-witted and easily bored people to run elevators, or sent city slickers with a large and high-flown vocabulary out to sell hog feed to sharecroppers. Even the best of the tests are successful only when used as they are supposed to be used, by trained psychologists — and the more modest psychologists at that. The less judicious psychologists who have gone into industry and succumbed to the lure of quick results and a quick dollar cause much headshaking among their more conservative colleagues.

Inside the office and factory the psychologists have discovered a number of interesting and useful things. They have learned, above all, that fatigue plays a much greater part in the workday than the oldtime businessman ever realized. The average worker, physical or mental, is at his peak early in the day, as soon as he has got warmed up to the job, and falls off fairly rapidly thereafter, until he is operating at half speed or less at the very end of the day. Even in wartime or other emergency it does very little good to increase the work week past 54 hours, because that is the limit of effective human capacity on a steady schedule. The average worker will get as much done in 54 hours as he will in 60 or 70. Decreasing the work week from 54 hours to 40, which is a matter of 26%, does not decrease output anywhere near 26%, for output per hour goes up as the number of hours goes down, at least to 40 per week and perhaps even fewer. (Creative workers, or those with exceptional incentives, are of course notable exceptions to all these generalities.)

Rest periods are a great help to efficiency; the worker who loafs now and again gets more done than the one who tries to keep going all the time. In one experiment girls on a labeling job raised their production 13% when given a 10-minute rest period in the middle of the morning. Girls assembling bicycle chains increased production — also, as it happened, by 13% — as a result of five-minute rest periods at the end of each hour. On more strenuous tasks, even more rest seems to be ideal; one psychologist has figured that a man doing light muscular work on an eight-hour shift must rest just about one-sixth of the time to be at peak efficiency. Industrial psychologists nowadays advise employers to provide rest periods as a standard and authorized part of the work day. It has been found that workers will take them anyway, at the water cooler or rest room, and that authorized ones are much more effective.

The most important factor of all when it comes to increasing production, however, seems to be worker morale, a subject which has occupied the industrial psychologist's close attention ever since a famous experiment at the Western Electric

Company in 1927. This started as a simple matter of illumination engineering; the company merely wanted to learn how much light would bring about maximum production in various departments where girls assembled telephone apparatus. But it was immediately discovered, to everyone's surprise, that as soon as the company began experimenting with the lights, production went up regardless of whether the wattage was increased or decreased. It even went up when an electrician pretended to change all the bulbs in a room but put the same ones back. Something strange was at work and the company spent the next five years trying to discover just what.

The company tried giving the girls rest periods, different hours, a shorter week. Production kept going up. Then all the new privileges were taken away. Production went up again. Finally there was only one possible conclusion: the girls working in the plant were responding to the attention being paid them, not to any specific form that the attention took from day to day. They thought the company was interested in them, they felt important and they worked harder. Their improved morale was more vital to production than all the physical aspects of their working conditions put together.

In contrast to the girls at Western Electric, men at the same plant were found to be less emotional about their jobs and far more concerned about practical matters. Even among men, however, numerous studies have shown that pay alone is not the crucial factor. Nor can a company "buy" loyalty through such devices as improving the cafeteria meals or running bowling contests, which have been tried and found ineffective. What counts most seems to be the warmth or coldness of the worker's relations with his foreman or supervisor and the amount of respect each has for the other. The attempt to teach supervisors how best to work with their employes has become a big part of the industrial psychologist's job.

Psychologists have known for a long time that one of the greatest problems in business and industry is the disturbed worker — the man or woman who is in such bad shape emotionally that happiness and efficiency on the job are almost impossible. A pioneer study at a Connecticut silk mill showed that mental and emotional disturbances caused more loss of time and money than all contagious diseases and accidents put together. Another early study of 4,000 people who had been fired from their jobs showed that nearly two thirds failed for reasons of social incompetence — poor relations with their fellow workers or bosses — rather than actual inability to do the job.

ACCIDENT-PRONE WORKERS

More recently a large statistical study of telephone operators disclosed that a mere third of them — all of whom had personal problems of one kind or another — were responsible for the bulk of all the absenteeism, illness and accidents. Other studies have indicated that in fact perhaps as many as 80 or 90% of all industrial accidents are due to human error of one kind or another, the bulk of them committed by workers who seem to have one mishap after another and are sometimes said by psychologists to be "accident prone." Many such workers show a pattern of having accidents on the same days of the week or at the same hours of the day. On the other hand some psychologists feel that the most difficult worker of all is the one who does not quite have an accident, does not quite get sick enough to stay home — but comes to the job in such a low physical state and such a bad mood that he pulls down the morale and efficiency of everyone around him.

Another problem worker who exists in considerable numbers is the alcoholic or near-alcoholic, who keeps his fellow workers busy covering up for him during his frequent lapses. It has been estimated that about two workers out of 100, or well over a million in all the U.S., fall into this class.

Some firms, among them du Pont, Metropolitan Life, American Cyanamid and Caterpillar Tractor, have decided to provide employes with the free service of psychiatrists or clinical psychologists. The consultations are often simply called "personnel counseling" to make them somewhat more palatable. Nobody yet knows how successful such counseling is. But there have been indications, as at the Oak Ridge Atomic Plant during the war, that even a small amount of on-the-job therapy has considerable effect and carries over into the workman's home situation, making him happier all around. It has also been found that providing "personnel counseling" reduces the work load of foremen and supervisors, who otherwise would have to spend much of their time listening to personal problems.

Counseling has its severe critics, however. Many union people refer to it contemptuously as "cow psychology" — an attempt to get more production out of the worker by keeping him placid and uncomplaining. Some psychologists agree, on the ground that any advice paid for by the company is almost bound to favor the company's desires over the worker's psychological needs.

Among those in industry who have been found to have their share of psychological problems are the executives. Perhaps they have even more than their share. The higher up in industry a man goes the more he is likely to worry about his chances of staying there, and the more opportunity he has for that common human failing of comparing himself unfavorably with his colleagues and competitors. To add to the tension, the executive has very few if any intimates to whom he can confide his problems. One executive visited the company psychiatrist out of worry that he was simply outclassed by the brilliant talents of his chief assistant. At the same time the assistant was visiting the psychiatrist out of fear that his own meager talents would never enable him to keep up with the boss.

The services of the psychologist at the executive level received considerable publicity some months ago from W. Harold Rea, head of Canadian Oil Companies, Ltd., in a speech before Toronto's National Sales Executives Club. Rea told of a company whose president had called in a psychologist to examine all the top men, including the president himself. The psychologist administered a battery of intelligence, aptitude and personality tests and interviewed all the executives in depth. At the end of the study the psychologist reported bluntly that the president was the chief cause of the company's difficulties — he was a worrier and a penny pincher, far too indecisive and unwilling to delegate authority.

After a spell of deep gloom during which he thought of resigning, the president was persuaded to stay on but to redefine the other executives' jobs, give them more authority and let them handle all problems except the big ones that really deserved his attention. As a result the other executives took a renewed interest in their work and the president's desk, cleared of unnecessary details, ceased to be a bottleneck. The company's sales and profits improved sharply. At the end of his speech Rea said, "The company I have been talking about is my own company. The chief executive I have been talking about was your speaker."

Not all company executives who have used the services of psychologists are so frank as Rea, and the results are not always so spectacular. But the use of psychology at the executive level seems on the rise. Several firms of consulting psychologists specialize in this service to the exclusion of all else. At least the psychologist can surely offer the executive more than the standard advice which he used to get from his family doctor — to take a Florida vacation if things became too disagreeable or to ask for a transfer if they became unbearable. The enforced idleness of an unwanted vacation or the added strains of a new job are just about the last thing an already harassed executive can use.

MAKING MACHINES CONFORM TO PEOPLE

Human engineering, another of the psychologist's contributions to industry, sounds offhand like an attempt by some hardhearted slide-rule expert to remake mankind in a more efficient image. Actually it is just the opposite: an attempt to make machines conform to people. The newest telephone handsets are perhaps the most widely known example. Their design was preceded by measurement of the faces of thousands of people, as well as numerous experiments in which sets of various weights were tried out on users. The new sets which grew out of these observations are lighter than the old ones. They are also shorter, and the mouthpiece is set at an angle which suits the maximum number of people. The dial numbers are outside the holes instead of inside, providing greater legibility and less wear.

All this sounds perfectly simple, but nobody was doing anything like it until recently. Most industrial design has been based on quite different principles — usually on what was easiest to make or what was done by tradition for many years. The home electricity meter with its half dozen little needles moving in different directions on a half dozen little dials is a flagrant example of bad human engineering and is gradually being replaced by a meter which can be read like the mileage on an automobile speedometer. The automobile dashboard whose instruments were reflected in the windshield was another human engineering error rampant a few years ago. Most factories and plants are themselves full of bad design: machines with controls in awkward places, work routines that require far too much stooping, bending and walking.

The widest use of human engineering has been made by the armed forces, which learned in

World War II that military equipment was getting too complicated and specialized for the men who had to use it. Gun turrets on Navy bombers were far too small for anybody but jockeys, and there was a limited number of jockeys in the draft calls. The Air Force had bomb sights which theoretically could hit a pickle barrel but due to human failure often missed entire cities. The Army had one vehicle which worked just fine except for a seat which vibrated so much that a monkey strapped to it was killed inside three hours.

Much of the early work in human engineering for the military involved such simple steps as changing the shape of aircraft control knobs so that pilots could tell by touch whether they had grasped the landing gear or flap lever. In the last 10 years the work has become increasingly complex and ingenious. Psychologists have now arranged to put many of the important airplane instruments into standard position, with the needles all pointing the same way when the plane is working properly. Better still, the Navy is working on a radically redesigned cockpit system in which practically all the instruments and dials will be replaced by two simple electronic "pictures" that the pilot can read at a glance.

In old-style submarines the controls have had to be operated by three men cramped into the tightest of quarters; the controls on the new atom-powered subs can be operated by one man in a comfortable chair. The psychologists are even anticipating maintenance problems and redesigning equipment so that it will be easier to repair as well as to operate.

The psychologists have also undertaken to simplify and improve military training. In some cases they have redesigned the equipment, as with a shipboard control system which once required four or five weeks of training before its operators were even fair at the job, but now might be handled perfectly by a 10-year-old boy on the first attempt. In other cases they have designed new training equipment which speeds the process. A spectacular example involves the Air Force K-bombing device, which weighs a ton and costs around $250,000. In the past there have never been enough of these expensive devices for the training of repairmen, who have had a very poor record because of lack of practice. Psychologists have built a simple little substitute, costing about $4,000, which gives trainees all the practice they need in finding the possible sources of trouble.

Similarly the Army has found that it can use $50 wooden tank hulls for much of its armored force training instead of tying up several hundred thousand dollars' worth of real tanks. The Air Force has found that its pilots learn just as well when they get their first 25 hours of flying instruction in a cheap light plane rather than one costing 10 times as much.

The great goal now in training, especially in the Air Force where so many new planes and missiles are coming along, is to have men ready to operate new apparatus before it even comes off the assembly line. The first experiment along this line was made just five years ago when a psychologist was given the specifications and blueprints for a new type of radar equipment. Actually the equipment was already in use, but the psychologist was not told this. With nothing but the plans to work from, he drew up a personnel chart which was substantially in agreement with the actual number of people and types of skill which had been found necessary to keep the equipment in working order. Ever since then the Air Force has assigned about a fifth of all its psychologists to concentrate solely on setting up advance training programs for equipment which will not be received for months and even years. This is the best and perhaps only way, the Air Force figures, to reduce the lag between design and actual use of equipment which makes so much of it obsolete so very fast.

In everyday civilian life one of the most famous applications of psychology is the Gallup poll. Before the science of psychological statistics came along, straw ballots were simply taken at random and with no thought to representative sampling. This led to the old *Literary Digest*'s notorious error in predicting a decisive victory for Landon over Roosevelt in 1936. Now polls like Gallup's are taken with every type of voter represented according to his actual proportion in our society: so many men and so many women, so many farmers and factory workers, so many rich people and poor. Questions are tested in advance to make sure they are not loaded in favor of one response or another. There is still a chance of error but it has been greatly reduced. Not all surveys, of course, are made under best statistical procedure — and it is a good idea to ask how the figures were obtained before believing them.

Polls have been widely used by government — for example to try to determine in the 1930's what kind of crop controls farmers would accept — and especially by business, which uses them to test the audience of television shows and the reaction to various types of advertising and public relations campaigns. The effectiveness of advertising slogans has been tested in this manner, with results showing that the number of people recognizing the slogan may vary from as little as 1 or 2% for a poor one to 70% for a really good one. Other surveys have shown that face powder sells better in a blue box than a green one, that tan automobiles are more popular in the West than in the East and that a blue-tinted box will sell eggs 30% faster than any other color.

A company once asked a research firm to test public reaction to a shoe preparation it was about to put on the market. The research firm reported that a great many women disliked the can because its border design looked like a worm crawling around; the company put out the product anyway and went broke. Another company spent a small fortune advertising the purity, smoothness and antiseptic properties of its talcum powder — only to find in a survey that 95% of its customers bought it because they liked the smell and the other 5% because they liked the shape of the can.

The newest psychological technique in the advertising field is called "motivational research," or MR for short, and is the subject of much violent argument among both advertisers and psychologists. It has long been known by the psychologists that we often behave as we do for motives completely different from the ones we like to think we have. Dislike of another person's race or religion, to cite a common example, is less often a considered opinion than a process of merely foisting off onto someone else our own frustrations and inferiorities. Similarly we perhaps buy new automobiles or bow ties for reasons which are not entirely obvious to us. Some of the motivational research experts in the advertising business claim that they can learn these motives and sell more goods by gearing advertisements to them.

Some of the things the MR experts do seem eminently sensible. One of them advised Pan American-Grace Airways to quit using pictures of pretty models to advertise its South American tours and instead show the kind of middle-aged couples who actually have the money to take such trips. Brewers were advised that they would get nowhere trying to sell their product as a luxury item but should direct their ads to the homey and comfortable people who drink the most beer. The company that makes Marlboro cigarets abandoned its strictly feminine advertising appeal in favor of the tattooed hand it now uses to attract men, who are after all the biggest smokers.

But other examples of MR are likely to stagger the imagination. One MR practitioner has come up with the theory that contributing or not contributing to charity is related to the toilet-training period, when the child first discovers that it can please or displease its mother by giving or not giving. Another claims that adolescent girls wash a lot to cleanse themselves of their emerging sex impulses, and that any soap manufacturer who is not ashamed to exploit this hidden motive can get rich.

MR is one of the aspects of psychology which sometimes make it seem like a dark and nefarious science of controlling man's soul and leading him around like any mechanical robot by pushing the right buttons. Another of these aspects is "psychological warfare," a term much publicized in recent years, with all its frightening implications of a science of persuasion which can lead men to fight or to lay down their arms without a struggle. There is no reason as yet, however, for lovers of mankind's individuality to abandon all hope. MR as an advertising weapon, as has been said, is still an object of much argument among the psychologists themselves, many of whom think it is largely nonsense. As for psychological warfare, this is still mostly a name, and not a very apt one. As one eminent psychologist has pointed out, it resembles the Holy Roman Empire, which was neither holy nor Roman, for it is neither good psychology nor any kind of warfare. What it is, really, is simply old-fashioned propaganda masquerading under a fancy modern name.

The psychologist has found, to be sure, some rather effective ways of appealing to our baser motives and designing propaganda for maximum effect. He has learned the startling fact that even when a piece of literature is presented to students as a horrible example of propaganda, it still often affects their opinions. Propaganda is not, however, a sure key to the control of human beings. One famous study of the 1940 election showed that voters exposed to all kinds of Republican and Democratic propaganda usually chose to believe only what they were already prepared to believe. Any astute observer who knew them at the beginning of the campaign could pretty well have predicted how they would vote, regardless of the pressures brought to bear on them. It was only those voters who were exposed to completely one-sided propaganda who showed any substantial change.

Thus any grave fears that the psychologist may some day betray humanity rest on two assumptions: first, that he will become infinitely better at influencing people than he has proved to date; and second, that all psychologists will gravitate to the side of evil. Neither of these seems very likely at the moment. Doubtless the psychologist will discover many techniques that would be at least moderately dangerous in the wrong hands or if used for the wrong purposes. But competition alone may well save the day. For every advertiser urging us to buy one brand of cigarets there will always be a dozen others attempting to lure us elsewhere. Moreover, the adult human being is infinitely complex and far more impervious to manipulation than we sometimes realize. The psychoanalysts have found that it often takes years just to understand all the diverse and complicated matters that have influenced our growing up, and that changing our adult personalities is always difficult and sometimes impossible.

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Aptitude Tests: Can They Steer You to Success?

STAFF OF CHANGING TIMES

Despite the successes of psychological tests in determining the best candidates for jobs (selection) and in helping a person find the work for which he is best suited (guidance), there are limitations to what the tests can do. It is just as incorrect to believe that from a test we get a *verdict* as it is to believe that all tests are worthless. Test results can be used by trained counselors to help make predictions, and predictions are probability statements, as this article clearly shows. Each year thousands of college students take psychological tests and profit from the counseling in the discovery of unsuspected assets and new career possibilities, or in the confirmation of a hoped for but unsure decision. The factors of intelligence and some of the more clearly understood aptitudes are also described in the article.

The selection which follows was prepared by the staff of *Changing Times* and appeared in the February, 1955, issue (pp. 19–22). It is reprinted by permission of *Changing Times*, the Kiplinger Magazine.

Three great moments of decision can determine whether your life adds up to a success or a fizzle. Your first big decision comes when you decide what line of work to follow. The right choice can start you toward success, and the wrong choice may lead you, groping and blundering, into a dead end.

The next great decision comes later. You wonder whether you are on the right track. Should you start again in a new direction?

Unexpected opportunity brings your third big decision. You have a chance to shift into a different line of work. Would you be wise to make the switch?

All three decisions are tough to make. You must judge your own strong points, weaknesses and capacity to meet the competition — then bet on your judgments.

Suddenly it comes to you. There *is* a way to take your own measure scientifically. Aptitude tests will solve your problem, tell you what you were born to do. You can take the tests, act on the results, and live happily ever after.

But hold on. Is it really that simple?

Not quite. Aptitude tests can help you find your way, but before you take a single one, get straight on these two points:

Tests can give you nothing but glimpses into your kit of talents and attributes. They cannot assure you, positively or money back, that you would click in any given job.

Just taking tests is never enough. Somebody, an expert, must interpret the results and help you relate them to your own circumstances. This help is called counseling.

The basic assumption of aptitude tests is that people are different and some kinds of people succeed in given jobs while other kinds flop.

But what makes one person different from another? What traits, when measured, predict whether you will make good or fail in a particular occupation?

YOUR INTELLIGENCE AND YOUR CAREER

Once it was thought that the whole question could be wrapped up in a single package called intelligence.

A lot of work went into devising intelligence tests, and into trying to link performance on these tests to career success.

This one-shot approach, however, had a serious shortcoming. Intelligence tests resulted in a score that placed you in relation to other people but not in relation to the demands of various jobs. No one knew what score you needed to become, say, a successful lawyer. As the psychologists said, there were no "occupational norms."

Two wars threw light into this dark corner. The Army tested men by millions. Since the Army knew what occupations its men normally followed, it became possible to see what scores were usually obtained by men in different lines.

It turned out that the highest scorers most often were accountants, mechanical-engineering students, personnel clerks, medical students, chemists and electrical-engineering students. The lowest scorers usually were teamsters, miners, farm workers and lumberjacks. The great bulk of occupations fell in the middle.

But it also turned out that there was much overlapping. Ninety percent of the accountants tested, for example, made scores of 114 or better. Yet more than 10% of the men in the lowest-scoring occupational group, lumberjacks, did that well, too. Obviously, it would be risky indeed to base a career choice on a score in a test where such dramatic exceptions to the rule could occur.

Nevertheless, intelligence tests still have a place in aptitude testing. If you undergo full-scale testing, you are quite likely to take one. And naturally, you will wonder what to make of your score.

Better let your counselor worry about that. Actually, not much is known on this subject. It is known that high scorers tend to make more realistic career choices and seem to hang on to their jobs better than low scorers. But there is no established relationship between intelligence and such generalized capacities as executive ability or sales ability.

How come intelligence tests yield so little useful guidance? Two reasons, mainly.

Research indicates that intelligence is not one trait but the sum of a sizable group of aptitudes. Career success, of course, does not depend so much on the sum as on being strong in the special aptitudes that count most in a particular vocation.

Also, there are many levels within any occupation. A chemist may do routine tests or the fanciest kind of experimental research or something in between. Intelligence may determine how high he rises. But intelligence alone will not determine whether he should be a chemist or an architect.

Since your IQ has so uncertain a bearing on your choice of career, waste no time gloating over a high score or brooding about a low one. The important thing is to identify the components of intelligence in which you excel.

The whole trend in intelligence tests is aimed at helping you to do this. Old tests, such as the Stanford-Binet, the various Otis tests, the Wonderlic Personnel Test, the Army Alpha and the Army General Classification tests, yielded only a total score, or IQ. Newer tests, such as the Wechsler-Bellevue intelligence scale, the American Council on Education Psychological Examination and the California mental maturity tests, have sections that measure particular kinds of mental ability with occupational significance.

HOW MANY TALENTS ARE THERE?

Psychologists are not agreed on how many of those special traits exist. One psychologist, E. L.

Thorndike, once speculated that there were only three types of intelligence, which he called abstract, mechanical and social. The work of other men has rapidly expanded this list. L. L. Thurstone, for example, made up a list of eight primary abilities: spatial, perceptual, speed, number, verbal relations, word forms, memory span, induction, and reasoning, or deduction. A few years later, a U. S. Employment Service study listed 11 basic aptitudes. And the Air Force, during World War II, compiled a list of 28 aptitudes.

Some of these traits seem to be related. If you are strong in one aptitude, you are likely to be strong in an allied one. But others appear to occur independently.

All this formed the basis for a great deal of research into which aptitudes were essential in what jobs. Dozens of tests to measure single traits were developed. You may encounter tests for such abilities as spatial visualization, manual dexterity or mechanical aptitude. You are more likely, however, to take combinations of tests known as test batteries.

One kind of battery is custom-built to determine fitness for a particular occupation. Most tests for the professions, such as the Moss Medical Aptitude Test and the Ferson-Stoddard Law Aptitude Examination, really are test batteries of this type.

The other kind of battery begins with the knowledge that each measurable aptitude is useful in more than one occupation, and aims at scores that indicate fitness for a number of occupations. That makes this kind much more useful than one-job batteries for those undecided about which occupation to enter.

MEET DAT AND GATB

Two multipurpose batteries you ought to know about are the Differential Aptitude Tests, or DAT, developed by the Psychological Corporation, and the General Aptitude Test Battery, devised by the U. S. Employment Service. This is known as GATB, or more familiarly, Gatby.

It took ten years to work out GATB. Now it is widely used for counseling by the Employment Service and cooperating public schools. One of its authors, Beatrice J. Dvorak, says it can rate your aptitude for several thousand occupations in a little more than two hours of testing, by means of "norms" for 20 fields of work, which are related to about 2,000 occupations.

The 15 tests that make up GATB are both the pencil-and-paper kind and the apparatus-manipulation kind. They produce scores for these ten aptitude factors:

Intelligence, or general learning ability and the capacity to understand directions.

Verbal aptitude, or the ability to understand words and express ideas in words.

Spatial aptitude, or the ability to "see" objects in space and their relationship.

Form perception, or the ability to compare and distinguish shapes and details.

Clerical perception, or the ability to see detail in tasks like proofreading.

Aiming, or the ability to coordinate the movements of your hand with what your eyes see.

Motor speed, or the ability to make hand movements rapidly.

Finger dexterity, or the ability to move fingers and manipulate small objects quickly and accurately.

Manual dexterity, or the ability to move hands and arms skilfully.

Numerical aptitude, or the ability to do arithmetic quickly and accurately.

The Psychological Corporation's DAT, on the other hand, tests for eight variables that are useful in vocational counseling and employe selection: verbal reasoning, numerical ability, space relations, abstract reasoning, clerical speed and accuracy, mechanical reasoning, and two language abilities, spelling and sentence structure. The time required to take DAT is three hours and six minutes.

WHO SOLVES YOUR PROBLEMS?

Now suppose you are in one of the fixes described at the beginning of this article. You are selecting a career, deciding about giving up an unsatisfactory one, or considering a promising new line of work that is unlike anything you have done before.

Can aptitude tests solve your problem?

The answer must be No. Tests do not say, "Become a taxidermist, and you will prosper." Nor can they promise success if you go the way they seem to point.

What tests do give you is a statement of your chances. They may say, in effect, "You shine brightest in these respects, which others have found useful in these lines." Or they may say, "Eighty out of 100 people with your type and degree of ability succeed in this line."

Notice the caution. The statements are about people who resemble you in some ways but not predictions about you, personally. For all the tests can tell, you may be among the 20 out of 100 who fail, not among the 80 who succeed.

There is more to success than aptitude, you see. Opportunity, your economic chances of getting the necessary training, your temperament, your physical stamina, your drive — all count, and tests do not evaluate those factors.

That is why you need a counselor to interpret test results and help you weigh those crucial facts in your case that are outside the realm of testing.

And don't expect your counselor to announce, "Go do thus and so." He may never give you any directive. Some just talk matters over and leave you to figure out the answers. Others search for a conclusion to recommend to you. Either way, you make the final decision.

"But if everything is left to my judgment anyhow," you may ask, "is all the rigmarole of testing and counseling worthwhile?"

Definitely. Testing double checks your hunches about what you are good for. It reveals facts about yourself that you never knew before. Counseling offers you the chance to explore your problem and potentialities with a sympathetic, well-informed adviser.

When it is all over, you will know yourself better than ever and have more facts to go on. You will not escape the responsibility of choosing your own fate. But after all, would you want it any other way?

QUESTIONS ABOUT TESTS AND JOBS

Will tests tell whether I am the executive type? Many psychologists believe that there is no such thing as an executive type. There are, rather, superior people in every line who become executives, probably because of the personality, temperament and drive they bring to their jobs. Executives are much like other people in their own lines, not much like other executives in other lines.

Can my interests indicate my best career bet? Your interests may have little to do with your abilities. Yet considered with other factors, they may point to a group of occupations suitable for you. They probably will not, however, single out the one "right" career.

The job interests of adolescents often change. But by age 20 a person has acquired pretty much the interests he will have throughout life.

Will my health affect my IQ? If you are well enough to be out of bed, you are well enough to take an intelligence test. Violent emotional upset, of course, might produce a poor showing. But a mild illness such as a cold or just "feeling under par" won't.

Only a very few emotionally unstable persons go to pieces during a test. And if you are under tension, you may even do better than otherwise. College freshmen who took intelligence tests during the height of the 1938 New England hurricane scored 20% above expectations, although retest showed that they were just average.

If I choose a career by test, will I be happy in it? Presumably, being well-suited for your job favors being satisfied with it. However, so many other factors affect job satisfaction — company policies, your ambitions, your adjustment to your life outside work, your worries — that high aptitude alone cannot guarantee that you will be happy at work, even though you are successful in your job.

Are my hobbies a cue to career choice? Not necessarily. Some hobbies are related to basic occupational interests, others are not. Model engineering is a hobby that is popular with people who have the same general interests professional engineers have. Stamp collecting, on the other hand, appeals to people of such varied job interests that it has little vocational significance.

WHERE TO GO FOR HELP

If you want the guidance that vocational testing and counseling offer, there are three types of places to seek it.

Try the local office of a state employment service affiliated with the U. S. Employment Service. Not all of them provide guidance services. Those that do, however, offer it free.

Private and public institutions such as colleges, schools and philanthropic agencies often give such services. The fees, if any, usually are nominal.

In most large cities there are professional consultants and counseling firms. Many are good and can give individual attention to your problems. Be sure to pick a reputable outfit. The American Personnel and Guidance Association, Inc., 1534 O St., N.W., Washington 5, D. C., publishes a directory of counseling agencies. You can get it from them for $1.

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Human Engineering: The Study of the Human Factor in Machine Design

LEONARD C. MEAD AND JOSEPH W. WULFECK

This article contains a description of still another area where psychologists have found an economically useful application of their knowledge of research, measurement, and control. In selection 61, Havemann briefly introduced the reader to human engineering. Now in the present article two psychologists who have worked in this area for a number of years describe the nature of their tasks. This example of teamwork between scientists of quite different training shows how each can gain and how together they can contribute to the solution of a technological need. This article describes two of the major interests in human engineering research — machine control and machine display — and gives an account of the practical application of basic psychological information. The theoretical model which is the basis for much of this work is the notion that man and machine form a loop in which the momentary condition of the machine is displayed to the operator, who reacts by making appropriate adjustments in the machine.

Dr. Mead is now chairman of the psychology department and Dean of the Graduate School at Tufts University and Dr. Wulfeck is director of the Tufts Institute of Applied Experimental Psychology where much work in human engineering has been done. The following selection appeared in the "Science on the March" section of the December, 1952, issue of *Scientific Monthly* (pp. 372–379). It is reprinted by permission of the publisher and the authors.

NOTE: The figures have been omitted from this selection, with consequent minor revisions in the text to maintain continuity. These changes have been made with the authors' permission.

In the foreword to the Tufts College *Handbook of Human Engineering Data* (1) Admiral Luis deFlorez says:

> The amazing progress of science and technology in our time, which has endowed mankind with virtually unlimited physical power, has brought with it a gigantic responsibility. Achievements such as the mobile power of the internal combustion engine, the conquest of geographical barriers by the airplane, the boundless communications made possible by electronics, and now atomic fission with all its ramifications have provided the means of performing miracles and producing catastrophes. . . . Up to the present, we have been able to keep up with technological progress by education and training. But we have now reached the point where the machine has dwarfed the man, for the characteristics of the individual — the human machine — have not changed in the memory of man and will not change for countless generations to come, while the man-made engine is capable of ever increasing power, scope, and speed of operation. We must, therefore, consider man's capabilities as a constant in contrast to the unending progression of the machine.

It is the purpose of this paper to summarize briefly some recent efforts that have been directed toward solving this dilemma. A few words of historical introduction may be appropriate.

Early in the Machine Age initial attempts to provide increased production consisted of greater employment and improvement of the machines themselves. The worker, or the operator of those machines, received little or no consideration. As early as 1829, however, it was observed that

> We have been very much occupied in perfecting the machines and tools which the worker uses in the economic arts. We have hardly attempted to improve the worker himself. However, if he were only considered as an instrument, a tool, a motor, he would necessarily be placed in the first rank of all instruments, all mechanical agents, since he has the immeasurable advantage of being an instrument who observes and corrects himself, a self-stopping motor which functions with the motivation of its own intelligence and which perfects itself by thinking not less than by work itself. (2)

Nevertheless, it was not until near the end of the nineteenth century that any real efforts were made to provide for coordination and integration of the capacities of men and machines. This movement was led by F. W. Taylor. Because of his efforts to simplify and standardize the motions made by workers in numerous industrial jobs, he is considered the founder of the fields of scientific management and motion study (3). Subsequent to his contributions, a number of other investigators, particularly the Gilbreths, developed the field of time and motion study, which has led to the well-established areas of industrial engineering known as time and motion economy and efficiency engineering.

Thus the first group to attempt to utilize human engineering principles consisted of engineers making contributions to what would now be called psychological problems. The field of industrial engineering, however, has concerned itself mainly with applications to existing machines, devices, and procedures. In general, the attack has not involved modifications in original design.

Somewhat prior to the birth of management engineering, it was discovered that a significant body of knowledge and information about basic human capacities and limitations could be gained by empirical investigations of human behavior rather than by philosophical deliberation. Experimental psychology was established as a field of endeavor about 1879, when Wilhelm Wundt founded the first experimental laboratory at the University of Leipzig. Experimental psychology spread rapidly thereafter and led to the early work done in laboratories at Cornell, Harvard, Columbia, Clark, and Johns Hopkins.

The growth in this field has constituted the core of what many regarded as the field of academic psychology as taught in most of our educational institutions during the first decades of the twentieth century. Experimentation in the area has generated a rather large body of knowledge concerning the capacities of the average human adult and the psychological nature of such functions as sensation, perception, learning, intelligence, emotion, thinking, motor responses, reaction time, and so on.

Another trend in which we are interested has been the study of individual differences and the development of personnel psychology (4). The first experimental investigations of individual differences were made by Sir Francis Galton and are exemplified by the tests, both psychological and anthropological, which he instituted at the International Health Exhibition in London in 1884. From this beginning the mental testing movement developed. We are all familiar with the intelligence and aptitude tests the development of which was spurred by the events of World War I; these were exploited thereafter for use in World War II.

During World War II, however, it was found that, even with the application of the best selection and classification devices then known, the most up-to-date training techniques, and the most refined techniques of time and motion economy, there were many instances where military operators were unable to perform the tasks which complex modern warfare and its instruments demanded (5). Time and time again it was found that the weapons, instruments, and equipment which engineers had produced, which were often ingenious applications from physics, electronics, and chemistry, were incapable of being operated proficiently by the average American GI. It became clear, for perhaps the first time, that the human being could be the factor that prevented an engineering device from performing to its full specifications, and striking experiences of this sort nurtured the notion that complex equipment must be designed with built-in human factor considerations.

The evolution of a field of human engineering was inevitable. It has as its prime goal the achievement of optimal man-machine relations. It asks the twofold question, How can the man be selected and trained to operate the machine most efficiently, and how can the machine be designed so that the man can operate it most efficiently? In one instance we select the man; in another, the machine.

Speed, power, computation, replication, simultaneous operations, and short-term memory are functions that machines can generally perform better than men. On the other hand, functions that men can (at least up to this moment!) generally perform better than machines include detection, perception, judgment, induction, improvisation, and long-term memory. The differences seem embarrassingly obvious, but one point requires emphasis. Machines can be modified or redesigned. Men can only be selected and trained to use what they have with maximum efficiency — the limits are firmly fixed.

An approach to the area of human engineering may be introduced and summarized with the statement that we are studying man as, or as a part of, a servomechanism, where the servomechanism matches an output with a varying input or reproduces the input at a higher power level. Certainly, when the human operator is considered in this light, it is clear that there are biological, psychological, and engineering aspects to the problems that arise. Ultimately we are interested in predicting the final over-all performance of a system that includes a human element; but the prediction cannot be made before the operating characteristics of all the elements of the system have been determined.

Although the servo-analogy may be extended to men working alone, men working with machines, or machines working alone, we shall concern ourselves with the single man-machine pair. To illustrate the human element in a simple servo-analogy, imagine a situation in which an operator must, by turning a crank, keep a reticle (hairline) lined up with a target. One can hardly maintain that the over-all efficiency of this unit is more or less dependent upon the machine element or the human element. Certainly the machine element has been well engineered, and those who engineered it have determined its characteristics of lag, slippage, stiction, friction, and torque as well as of linearity of response. Likewise, the human element has been rather nicely engineered, in spite of the fact that human engineers were not consulted in the planning stage. It becomes one of the first tasks of the human engineer to know or determine the characteristics of the human element that are important in a particular situation.

Returning to the servo-analogy for a moment, we can say that the human engineer must know or determine the following in this situation:

1. The sensory capacity of the operator. How well can he discriminate changes in target-reticle relations?
2. Sensory-motor capacity of the operator. How rapidly, consistently, and accurately can he initiate a movement in response to a change in target-reticle relations?
3. Motor capacity of the operator. What kinds of movements can he make? How rapidly, accurately, and consistently can he make them? How much force can he apply?

In addition, either the engineer or the human engineer must know or determine the characteristics of the following:

1. The input provided the operator — in this case the relation between target and reticle.
2. The input demanded by the machine — how much torque, friction, or inertia must be dealt with?

Given the foregoing information, we can answer the questions: What does the operator have to respond to? Can he respond to it? How rapidly? How accurately? How consistently? What are the force and rate requirements of the machine? Can the operator meet them? Consequently, we can predict the over-all performance of the system. If we should find that predicted performance fails to meet specification, we can readily determine why and take steps to bring performance up to specification.

To proceed from the foregoing specific example to a generalized analysis of a single man-machine system, we find that the design problems encountered can be categorized as either *display* problems or *control* problems. By a display we simply refer to those aspects of a device that provide sensory input to the operator. The display may, of course, be visual, auditory, tactual, kinesthetic, or other, although we usually think of displays as involving the presentation of visual information. By a control we mean that aspect of a machine whereby the motor responses of the operator direct the machine in its proper function. We are referring to such familiar objects as wheels, knobs, levers, switches, pedals, etc.

Let us consider the general field of instrument displays. Any particular display may be either *pictorial* (realistic) or *symbolic*. A typical road map, for instance, attempts to give information in realistic and natural fashion without distortion of critical relations, whereas a symbolic display may bear no clear, simple relation to the way the information would be perceived through man's sense channels if it were received in the natural environment (6). The familiar mileage chart, with its horizontal and vertical columns of numbers representing distances between cities, is an example of symbolic display giving the same information as the realistic display; the information here has been transformed into an abstract numerical and letter scale.

Although our illustrations may imply that only visual displays may be either pictorial or symbolic, the same dichotomy may be drawn for other types of display. In audition, sonar yields a symbolic display, whereas a direct listening system presents a realistic display. Speech forms, for the most part, a symbolic display; however, the onomatopoeia, although rare, may be considered a pictorial display. The dichotomy may be carried further to a comparison of the musical forms of Bach and Debussy.

In tactual displays the dichotomy also appears. Ordinarily knob controls in aircraft are uniform in shape — symbolic displays. Recently, though, control knobs shaped like the member they control have been tested; i.e., knobs for propeller or flaps have been shaped like propellers and flaps — pictorial displays. A recent study (7) has evaluated our capacity to discriminate between knobs having letter shapes by means of our sense of touch.

A pictorial, or realistic, display has the advantage of being easy to interpret because it is normal to our everyday perception; it is especially adapted to show relational information — the extent to which something is more, less, bigger, smaller, farther, nearer, etc. Examples are polar coordinate plots and television pictures. Unfortunately, however, a pictorial display is often very difficult to adapt to a particular machine situation, especially in the area of audition.

Symbolic displays are the kinds which are more commonly used and with which we are most familiar, even though they lack the advantage of having perceptual naturalness; examples are tachometers, clocks, pressure indicators, many kinds of charts, tables, etc. Symbolic displays are more accurate, and they are best suited for the presentation of discrete single-item types of information. Also, of course, being more conventional, more people are willing to use them.

If we classify the various functional uses of symbolic displays, we find that they fall into three main groups. The first and simplest function of a symbolic display is that of *check reading*. In this instance, all that the operator learns from the instrument is whether a particular situation exists. Examples are warning and indicator lights, sound alarms, or electrodes in your easy chair that may be used to show whether the cellar light is on or which one of the main dynamos has developed a malfunction.

A second major use of a symbolic display is the indication of *qualitative* information. In this instance we are interested in determining not only whether a particular condition exists, but whether the condition is changing in a desirable or an undesirable direction. Oil gauges or variable frequency sirens provide examples.

The third and most conventional use of a symbolic display is to show *quantitative* information in abstract numerical form. The clockface circular dial showing miles per hour, pounds per square inch, revolutions per minute, etc., is a common illustration of what we have in mind here, although many other kinds of information may be presented in dial shapes that are horizontal, vertical, semicircular, or of an open-window form.

Considerable human engineering research on quantitative visual indicators has been performed during the past few years. Without going into the details of the research, we shall simply list some of the questions of dial face design that have now been answered (*1*, *8–10*):

1. What should be the size of the dial and its elements? This question includes a consideration of viewing distance, numeral size, graduation mark size, pointer size, etc. Its answer requires information on visual acuity and resolution of the eye.
2. What should be the characteristics of the scale? Where is the origin — the null position — if any? Should the scale be linear, logarithmic, unit, or decimal? The information required here involves rather complex perceptual functions.
3. Under what conditions of illumination can the dial be used effectively? This question requires information regarding visual acuity, brightness discrimination, contrast sensitivity, and color vision.

Information of this kind is useful in many domestic, commercial, industrial, and military situations. Consider the growth in aircraft instrument panels over a twenty-five-year period. In the 1920's pilots had few instruments and relatively little to watch inside the cockpit; the 1930 cockpits were complicated mainly by the addition of multiple engine controls, but they were still within the capabilities of a single pilot's comprehension; the complicated cockpit of a modern air liner requires the combined and continuous attention of two or three men. Bringing the instrument panel up to date required the addition of some 20 or 30 indicators. To this complexity add the instrument reading requirements of high altitude, high speed, and, especially, night and all-weather flight and then require that a large amount of attention be given to intricate motor responses and to communication within and without the aircraft. It is not surprising that a recent survey conducted by psychologists at Wright-Patterson Air Force Base showed that a large proportion of military aircraft accidents or near accidents attributed to pilot error could be traced to errors in reading or interpreting instruments. An aircraft accident today often involves civilians on the ground, several men in the crew of the ship, thousands of hours and dollars spent in the training of the crew, and a million- or multimillion-dollar piece of equipment. If research on any of the questions posed above contributes to simplifying the pilot's job and reducing pilot error, that research would appear well justified.

As a single partial instance of the accomplishment of such research, consider for a moment the relative ease of reading of the old and new altimeter faces. The old type had three pointers, similar to the hands of a clock, with the shortest hand indicating 10,000 foot units, the middle hand indicating 1,000 foot units, and the longest hand 100 foot units. The redesigned altimeter has only one pointer, which shows 100 foot units, while the larger units show as numerals in a window like the mileage indicator on an automobile dashboard. Almost 75 percent of altimeter reading errors are eliminated by the redesigned instrument (*11*).

Beyond the separation of auditory displays into realistic and symbolic, it is possible to identify two classes of auditory information. Auditory signals may be either tones (signal alarms, code transmission, etc.) or noises (the symbolic sounds used in voice communication).

As an illustration of the manner in which the data of audition are employed in an engineering application, we may consider a system such as echo-ranging sonar. Neff and Thurlow (*12*) have summarized the kinds of auditory discriminations required of the sonar operator as:

1. Detection of a tonal signal masked by a background composed of an irregularly modulated tone and of noise, the signal differing from the background principally with regard to loudness or pitch. The rate of change of loudness — the abruptness of the echo — is also a factor to be considered.
2. Recognition of changes in the tonal signals masked by the tonal and noise background, the changes being those of pitch, loudness, duration, and quality.

The human capabilities and limitations for the perception of tones and noises are fairly well mapped out. Besides loudness and frequency thresholds, the ability of the ear to detect changes in pitch as a function of the frequency of the signal being perceived is known. The ability to detect changes in loudness as a function of the loudness level of the signal is known. More complex relations, such as the effect of varying signal-to-noise ratios on percentage of articulation or comprehensibility of speech sounds as a function of the loudness of the speech signal itself, have been determined. As a matter of fact, it is now believed by many that the development of communication equipment for the transmission of tones or the noises of speech is primarily a matter of engineering design and economic factors rather than a need for additional information concerning human auditory perception. There exists at present, however, a vigorous research and development effort by human engineers as a part of the contemporary emphasis on communication theory (*13*, *14*).

A third important quantitative symbolic display involves the presentation of tactual cues. Some data are now available for situations in which touch alone is used to obtain sensory information. This would be true if one manipulated controls in the dark or if the eyes were otherwise occupied. There is now available a series of eleven knob shapes that have been shown by experiment (*15*) to be seldom confused with one another. In other words, in a situation in which one had to rely solely on the feel on the control, these shapes would offer the possibility of eleven different knob contours for an equal number of control channels, with the minimum possibility of confusion among them. Although research on tactual displays has been limited, certainly other possibilities exist for the presentation of information through the tactual modality (*7*, *16*).

Although most, if not all, research on displays has been directed toward the development of visual, auditory, and tactual displays, other sensory channels are available and invite the role of utility. As a single example one may note that olfactory displays are already in use to warn of the presence of noxious gases, escaping refrigerants, etc.

The foregoing mention of knob design can serve to introduce the second major area of human engineering, which has to do with the design of machine controls for optimal human use. Here the information which we have is neither as great nor as well organized as in the area of the design of machine displays. All too often we find that research done in the area of control design has yielded information which does not fit the results of other investigations. It is difficult to perform research which yields immediately applicable data in this field because, as we pointed out earlier, prediction of the over-all performance of a man-machine system depends upon knowledge regarding all elements in the system. In a control system, however, both the man and his machine must be regarded as transmission elements, and little basic information concerning the transmission characteristics of the human operator, his operating ranges, and his susceptibility and adaptability to expected operating conditions has been available. Consequently, a great deal of current research in the area is basic in nature and has yet to be systematized to the point at which broad principles are available for application to control design (*8, 17–23*).

The information available concerning the design of machine controls for human use may be discussed under two general headings:

1. *The design and layout of the work place.* A great deal of the data which the human engineer draws upon when considering the design and layout of the work place has been made available by applied anthropologists, industrial engineers, and motion and time study specialists (*9, 10, 24*).

Anthropologists have accumulated great masses of data concerning almost every bodily dimension of various large as well as selected populations. In addition, they have established norms for many different human functions in answer to questions such as the following. How much can a man lift? How much can he push and pull in standing, sitting, or prone positions? How far can he reach, and in which planes are reaching and other motions most accurate? Data like these are all-important in designing seats, aircraft and automobile controls, etc., and need no further elaboration.

Industrial engineers and time and motion specialists have supplemented and extended the kinds of data obtained by the anthropologist. Principles of work place layout have been established which incorporate information on the bodily dimensions of the human operator, as well as the principles of time and motion economy. In addition, the field of time and motion economy itself provides such a wealth of data useful and important to the human engineer that it would be impossible adequately to sample the area with the brevity demanded here.

2. *The use of the human body.* We have already indicated that the human operator has been conceived of as, or as a part of, a servomechanism. As a matter of fact, our description of human engineering has been based on the treatment of the human operator as a link in a servo-system the over-all characteristics of which can be specified only after specification of the characteristics of all the links. Since Norbert Wiener published his book *Cybernetics* (*25*), however, engineers have been much concerned with the question of whether the human operator does, in fact, behave like a servomechanism, not simply as a part of one. In any servo-system, the input drives the output, and the input is corrected by the amount of error or deviation between what the input was and what the output was intended to be. Thus the output feedback, or error, is led back to the input, and a continuous correction is made. The analogy that has been drawn here is that of the kinesthetic spinal reflex wherein the sensory input provides information regarding the extent of a muscular response, which in turn gives further sensory input and thereby directs the response even further.

Certainly many other analogies may be drawn. In studies of the human being as a closed servo-system, however, it has been discovered that he reacts in a very complicated fashion and that the mathematical representations of man as a servo-system are probably not linear equations. At the present time, therefore, we are not in a position to say whether the human control operator functions exactly as a servomechanism. Yet the concept of the human operator as an element in a servo-system appears to be a useful one, and the specification of the characteristics of the human element remains the province of human engineering.

Directed at a better understanding of how the operator operates, a great deal of research on human motor and perceptual motor skills is under way. Among the questions here are: How rapidly and accurately can a man track a moving target? With what sorts of control members (knobs, wheels, cranks, levers) is he most facile? What should be their dimensions for optimum performance? How accurately can the operator duplicate certain control forces and what force-displacement relations should be incorporated in control member design?

The area of motor and perceptual motor skills has been further complicated by the advent of high-altitude, high-speed aircraft in which excessive acceleratory, or high "g," forces are common. In addition to protecting the operator from excessive g, it is necessary to design control members that can be operated by bodily members made heavy and sluggish by the effects of high g (*26*).

Although our treatment of the use of the human body and motor skills has been somewhat spotty, there is to be found quite a large body of more or less integrated detailed data. Current research on motor and perceptual-motor skills is progressing so rapidly at several research centers that it is the fastest growing area of human engineering and may shortly become the area of most concerted research effort.

In our dash through the field of human engineering we have touched upon only two of the major areas, those of machine display and machine control. Other topics we should have considered have to do with the effects upon human performance of various physical aspects of the environment, such as temperature, ventilation, humidity, noxious gases, noise, motion, and light (*1, 9, 27*). Communication systems and theory should have been discussed (*13, 14*). It would have been a pleasant vagary to speculate on the human engineering aspects of interstellar flight (*28*), but let us conclude simply by restating that one of the important phenomena of the past decade has been the recognition of how important the human factor is in engineering design, and noting with satisfaction the large and numerous contributions which engineers, psychologists, and biological and medical scientists are making toward the solution of these newly realized technological problems.

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*The Counselor Says "M-hm"**

DANIEL MALAMUD

Of all the areas of psychology devoted to the application of psychological knowledge to human needs, clinical psychology has shown the most dramatic development. In this selection Dr. Malamud describes the nondirective type of counseling employed by clinical psychologists in helping people toward a more satisfying life. Notice that the client works out his own problem and that the psychologist does not tell him what to do. Thus, the individual retains control of his own readjustment. Psychotherapy, as the process is often called, is not therapy in the medical sense, but is a learning experience for the troubled individual in which he gains insights about his own psychological dynamics. The brief bits of examples contained in this article help to show how the therapy works.

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"It wasn't what I expected at all. He just listened to me talk, said 'M-hm' a good deal of the time, didn't give me any advice or anything like that, and yet I feel that he helped me a lot. It was almost as if I were talking to myself, but with someone listening and trying to understand me. Blowing off steam right out loud like that and hearing it made me think about it, and helped me see things in a new light!"

That's the way a GI veteran summed up his experience with a new kind of counselor — one who helps clients solve their personal problems in their own way without giving advice. These counselors have come to believe that they have no right to direct a client's life. They feel that an individual must choose his own goals, and that if he gains enough understanding of himself and the nature of his problems he will make such choices wisely.

These counselors let the client do most of the talking. They encourage him to explore his problems and feelings freely, and come to his own solutions. They do not ask probing questions. They do not approve or disapprove of the attitudes he expresses. They do not tell him what they would do if they were in his shoes. This type of counseling focuses on the client — his feelings, his problems, his decisions. It is nondirective and client-centered.

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* The author is grateful to Dr. Carl R. Rogers for permission to quote brief excerpts from his writings. Examples given are reprinted by permission of the copyright owners from *Counseling with Returned Servicemen* (Rogers, Carl R., and Wallen, J. L. New York: McGraw-Hill, 1946).

Many other counselors, however, use a different approach. When someone comes to them for help they "take over." Like a doctor intent upon making a diagnosis, they ask many questions about the client's problems and symptoms and finally decide just what the trouble is and what caused it. Then, by means of pep talks, subtle suggestions, or logical arguments, they persuade the client to follow definite courses of action that they feel are for his own good. In the extreme of this type of counseling all the client has to do is answer the counselor's questions and follow his recommendations. This kind of counseling is directive and counselor-centered.

More and more counselors are beginning to feel that such directive techniques, in most circumstances, are not really helpful at all. Sometimes the initial problem that the client brings to the counselor is only a surface symptom of a more deeply underlying maladjustment. For example, it is well known that many students seeking vocational or educational guidance are really troubled by more basic difficulties. Yet, some counselors, because they take the initiative out of the client's hands and concentrate on the first problem presented, may miss this underlying maladjustment entirely.

Sometimes when a counselor takes the responsibility for solving a client's problems he may find the "answers," but at the expense of making the client a more dependent individual. The client may feel inferior because he had to lean on someone else for help. As a result, he may feel less confident to handle future problems on his own.

Some clients secretly resent being told what to do. Although they may listen passively enough, they will not follow the counselor's advice. Perhaps they have always rebelled against authority. Perhaps they feel their integrity is threatened. when they are told what to do. Some clients, believing they have not been given the right advice, shop around until they find a counselor who tells them what they want to hear.

Sometimes clients are unable to follow the suggestions they get from counselors. Advising a depressed person to buck up or an alcoholic to control himself is like telling someone to pull himself up by his bootstraps. People may be able to force themselves into states of cheerfulness or self-control, but usually for short periods of time only. When the almost inevitable relapse sets in, they are left feeling worse than when they started. They believe they are spineless weaklings without will power.

The unsuccessful experiences of many psychologists and psychiatrists with this latter type of counseling has led to the evolution of the nondirective approach. Dr. Carl R. Rogers, professor of psychology at the University of Chicago, has most clearly defined this type of counseling. In his two books, *Counseling and Psychotherapy* and *Counseling with Returned Servicemen* (the latter written in collaboration with Dr. J. L. Wallen), Dr. Rogers has given clear expression to his belief that many individuals can work out their own problems better than anyone else could do it for them — provided they get a chance to understand themselves better.

In a majority of cases, nondirective counseling goes through three main phases: in the first, the client freely talks out his problems; in the second, he gains a better understanding of himself; and, in the third, he decides what definite actions to take. These phases don't always come in one-two-three order; they often overlap. But they have been so frequently noted that their appearance is one of the most predictable characteristics of nondirective counseling.

In the first phase, the client is encouraged to talk freely about his problems and his feelings about them. The counselor encourages him by means of attitudes and techniques which, although seemingly simple, are extremely difficult to acquire. He is friendly and receptive. He neither feels nor shows approval or disapproval. At times he says nothing more than "M-hm," "Yes," or "I see" — remarks that indicate simple acceptance. Frequently, he will restate what the client has said in such a way as to reflect and clarify the feelings expressed. Sometimes the feelings are those of despair, or hostility, or guilt — but whatever they are, the counselor, by recognizing them and reflecting them back to the client, creates an atmosphere in which the client recognizes he is being understood and accepted for what he is. Several examples might be given. The first one is taken from a case of an aviation cadet who was failing in his solo flights:

CADET: I should have soloed long ago. And here is something. Before I joined the Navy I was an overhead electrical crane operator, and that takes depth perception, coordination, and alertness; and I'm positive that I can apply that to my flying.

C: You feel that your training as a crane operator should help you in your flying.

Cadet: That's right. And here's something else . . .

The second example is from an interview with a serviceman who was AWOL:

Dan: Well, it's a long story. I was drafted and I didn't want to go, but I went. I was sent to "X" Field for my basic training. I didn't like that at all. It was very dull, and there was nothing to do in town, and I found that all the interests I had at college were slipping away.

C: The whole business of getting into the army was pretty distasteful to you.

The third excerpt is from an interview with a bride of twenty who came to the counselor because she could not work in her disturbed emotional state:

Mrs. B: It's me and my husband. He's a sailor. We don't get along. I only knew him a week before I married him. Then he was overseas for a year, but now he's been home on a 30-day leave. It just didn't work out.

C: I see.

Mrs. B: He still loves me, but I don't love him. I don't think I did when I married him.

C: You doubt that you've ever had much feeling for him.

Mrs. B: He's nice in some ways. We talk together for hours about music and things. We have quite a little in common, but I just feel I was too young to get married. I'd be missing something if I stayed married. I want to go around with other fellows. I'm not ready to settle down!

C: You don't want to be tied down to one man — at least not yet.

The more accepting and permissive a counselor is, the freer the client becomes to dig deeper and deeper into his feelings. He begins to see that any of his attitudes, both negative and positive, can be brought out into the open. He sees that he needn't worry that the counselor will criticize him in any way. He finds that he can drop his defensive front. He becomes free to look at himself and his problems objectively without having to protect or justify himself.

Thus, the client enters a second phase in which he begins to understand things about himself that he didn't realize before. Things that were once unrelated now seem to tie up. He sees his problems in a new light. For example, in the case of the aviation cadet, counseling uncovered an intense hatred for his unreasonably strict father. Gradually the cadet began to see the connection between his attitude toward his father and his resistance toward his flight instructor's directions:

Cadet: You know after the last interview I wondered what made me tell you the things I did. Could it be possible that the instructor is a symbol of my father? Is that hatred coming back to blot my memory? Could that possibly be significant?

C: You wonder if perhaps the instructor might be a symbol of your father?

Cadet: Yes, he was telling me what to do just like Dad always did. I fully intended to carry out the instructor's directions; I couldn't not want to do them. Maybe I forgot because I thought of Dad and wanted to forget.

Mrs. S, a young, highly educated mother who was having trouble with her boy, began to face the underlying rejection of her child:

Mrs. S: I'm afraid I'd have to say this of myself, I really didn't want Buddy. We were married two years, and I had a job. My husband didn't want me to work. We thought children would be the best solution. We felt social pressure too. With the birth rate up in the lower groups, college graduates should have children. In a limited way we were emotionally interested in him, but not deeply. And I've never adjusted to having him! It's terrible to say this!

One client saw the relation between himself and his brother in a new light:

Client: I see now why I resented my younger brother so much — why we have never been able to get along together. It was because I was envious of the attention my mother showered on him. It wasn't because of anything he did. And all this time I thought it was because he was so unfair and mean.

In the second interview the young bride talked about her unhappy home life, how she was "farmed out" to relatives, how she gradually developed the feeling that you "grabbed onto everything you could get, and hung onto it." She realized that this was the reason why she could not be generous to others and sacrifice anything for the sake of her marriage. As the interview drew to a close she said, "Maybe it would help if I just grew up."

In the third phase of counseling it is fascinating to watch the client begin to make positive decisions and to act consistently with his insights. These decisions are likely to stick because they come spontaneously from within. They grow out of the inner needs of the client himself, not in response to an outsider's advice or persuasions. For example, the soldier who had gone AWOL and talked out his situation with a counselor concludes, "I realize I've got to go back and face the music." He adds realistically, "There is no use in pretending that I won't be afraid when I go back."

Another soldier, after realizing that he didn't go to parties and dances because he feared doing the wrong thing and being rejected by others, decided to develop social skills such as dancing in order to fit in better with other people.

The young bride began her last interview by saying that she had tried being generous and thoughtful toward two of her friends and found to her surprise that it worked. They did not take advantage of her generosity, and she felt much better within herself. She spoke of her marriage in a new way: "I've decided I'm going to give marriage a try. I've never really done that. We may not be able to make a go of it, but I'm certainly not going to give him up and give up our marriage without really working at it."

As the client takes hold of his own life and feels the original strains reduced, he takes the initiative to break off the counseling contacts. He feels as if he has matured during these counseling sessions. He feels that he has not only solved his original problems, but that he is much better prepared to face whatever future difficulties may arise.

The nondirective approach relies heavily on the individual's own drive to achieve better adjustment. It permits the individual to choose his own way of life. It does not set the counselor up as superior to the client. It does not attempt to impose any set of values or beliefs on the client. It truly respects the individual's right to decide his own problems for himself.

A growing number of professional workers have become interested in the nondirective approach. They have found it effective with the majority of servicemen, students, children and parents, and other adults with adjustment problems. It also seems to have possibilities for the extremely maladjusted or abnormal, but experience in these extreme fields is limited and no definite conclusions can as yet be drawn.

In addition to defining nondirective techniques, Dr. Rogers has gained widespread recognition for taking the counseling process out of the mysterious realm of art and studying it as scientifically as any other human behavior. By means of phonographic recordings of counseling sessions, he and his students have been able to make objective analyses of just what goes on between the counselor and the client. Also, by means of objective psychological tests, they have successfully measured the changes in personality brought about by counseling. These accomplishments make possible scientific comparison of the different types of counseling approaches — an achievement of the greatest significance for applied psychology.

Dr. Rogers has used phonographic recordings not only in research, but also as an aid in training future counselors. The counselors-in-training, by playing back records of their sessions, analyze their mistakes under the supervision of experienced counselors.

Nondirective principles may apply to fields other than individual counseling. A beginning has been made in the use of these principles in group therapy. Nondirective interviewing in opinion polls promises to eliminate much of the factor of bias. The implications for education, industry, and social relations challenge the imagination.

Dr. Rogers himself emphasized the potentialities of his approach when he stated:

> What we now know or think we know about a client-centered approach is only a beginning, only the opening of a door beyond which we are beginning to see some very challenging roads, some fields rich with opportunity. It is the facts of our clinical and research experience which keep pointing forward into new and exciting possibilities. Yet whatever the future may hold, it appears already clear that we are dealing with an orderly and predictable process which may prove as significant a basic fact in social science as some of the laws and predictable processes in the physical sciences.

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Beware of Psycho-Quacks

STAFF OF *CHANGING TIMES*

As the services of the clinical and counseling psychologists have come into greater demand in institutions, clinics, and other places, untrained and inexperienced persons have "hung out a shingle" and practiced as psychologists. Unfortunately it is not always easy for the layman to distinguish legitimate practitioners from the phonies, quacks, and charlatans. But since psychologists recognize that the practice of clinical psychology involves a heavy social responsibility, the profession itself has taken an active interest in protecting the public from the fakers. This article describes the education and experience necessary for qualification as a psychologist, enumerates some of the signs and techniques of the "psycho-quacks," and tells how to find a genuine psychologist.

The selection that follows was prepared by the staff of *Changing Times* with the cooperation of the American Psychological Association central office staff in Washington. It appeared in the issue of August, 1957 (pp. 11–13), and is reprinted by permission of *Changing Times*, the Kiplinger Magazine.

There are understandable reasons why the field of psychology is invaded by charlatans who prey on sick minds and emotions.

The profession of psychology is so young that its work is only dimly understood by the public.

Though the profession has been growing fast, with the number of psychologists doubling in the last seven years, qualified practitioners are still scarce.

Only recently have a few states begun to protect the public with laws controlling the practice of psychology, and the laws that are on the books are hard to enforce.

It is easy for a faker to pick up high-flown words from books, add mumbojumbo of his own and sound more expert than the experts.

Finally, and maybe most important, people with problems want pat answers. Legitimate psychology works slowly and cautiously. The psycho-quacks offer immediate, black-and-white diagnosis and promise sure cures quickly.

Incidentally, the phonies don't often pose as psychiatrists because these must be M.D.'s under the control of medical-practice laws. Psychologists hold academic but not medical degrees.

So it is in this fertile ground that the charlatans flourish, clustering in big cities like Los Angeles, Chicago and New York. Though they list themselves loosely as "psychologists," the phonies have also adopted or invented a large number of scientific-sounding specialties. There are among the phonies people who pose as graphologists, scientologists, astrolotherapists, numerologists, theosophists, hypnotists, metaphysicians, dianetics auditors, etc.

Many patronize diploma mills that for a price will confer almost any degree you want. One school issues authentic-looking diplomas in psychology for $16. Others ask much higher prices but no more effort.

Before taking a harder look at the quacks and how they work, learn first about the men and women they are trying to imitate.

LEGITIMATE PSYCHOLOGY—HOW IT WORKS

The nation's 16,200 psychologists are highly trained scientists in an exacting profession. Their college degrees range from bachelor of arts in psychology to doctor of philosophy in psychology.

About half hold doctorates. To be accepted into the American Psychological Association (which includes most qualified people), a psychologist must have done his studying at an accredited college. In addition, at least a one-year internship is required.

Psychology has been divided into some 18 divisions, representing the different specialties of its members. The field discussed here is clinical psychology, which deals with individuals, their problems and their emotional adjustments. In this specialty (and in two allied ones), the APA confers diplomate status through its American Board of Examiners in Professional Psychology. To qualify, a psychologist must be a Ph.D., have five years of experience and pass rigorous examinations by the board.

Most clinical psychologists work in institutions and mental health clinics as part of teams that include psychiatrists and social workers, and a few hundred practice privately.

The APA recommends that only diplomates in clinical psychology practice by themselves — and that they maintain collaboration with medical doctors. This means that a psychologist who hangs out his shingle should have at least 12 years of training for his job. Yet the psycho-quacks, with whom these qualified men and women must compete, can enter a school, graduate and start practicing in a matter of days.

What do the legitimate clinical psychologists do? In brief they are qualified to help an individual work out personal, emotional, educational, social and personality problems as well as marital, family and sexual difficulties. They deal with the school and behavior problems of children and give vocational guidance and do aptitude testing.

Diagnosis of maladjustment can be made through psychological testing and through interviewing. Help comes through many hours of psychotherapeutic counseling, the aim of which is to help the client understand himself and his problems. Some psychologists have special training in psychoanalysis and use this technique.

Eleven states have in the past ten years passed statutes regulating psychologists, and some 20 others are now considering legislation. In Arkansas, Georgia, Kentucky and Tennessee, anyone offering psychological services for a fee must be licensed by a state examining board. Seven other states — Connecticut, Maine, Maryland, Minnesota, New York, Virginia and Washington — have nonmandatory certification laws. Under these an applicant who wishes to use a particular state designation (as "certified psychologist, Virginia") must pass board requirements. Some of the states insist upon a master's degree from an accredited school, and others demand a doctor's degree. From one to five years' clinical experience is required in addition to the degree.

NOW, THE PHONY VERSION

If you live in a fairly large city, turn to the listings in the telephone book's yellow pages under "psychologists." Standing out among simple, one-line listings in this generally reliable book, you will probably find a hodgepodge of beguiling ads with names followed by impressive-sounding degrees you never heard of or by references to ologies and isms you can't define.

SIX SIGNS OF A PSYCHO-QUACK

1. He advertises and boasts of his qualifications and abilities.
2. He talks about his other clients, even using their names.
3. He may make a physical examination. A legitimate man will send you to an M.D. for a checkup and won't prescribe even so much as an aspirin.
4. He gives a quick diagnosis of your troubles. A real psychologist steers clear of labels, even after long examination.
5. He talks excessively. The psychologist spends most of his time listening.
6. He promises a cure — sometimes even stipulating the amount of time or money required.

The ads may read something like this: "Don't worry. Begin to live. See your psychologist." Or they may offer "sympathetic help" in "strict confidence." Or promise "processing" that will lead to "re-evaluation of the subconscious and reactive mind for better survival."

In interpreting the listings, bear in mind that the APA frowns on any advertising other than a listing of the psychologist's name and degrees and the types of services he is prepared to offer. Remember, too, that legitimate psychologists "counsel," but never "advise," "process" or "solve." And they would think it unnecessary to promise sympathy and strict confidence, since both are part of their professional canons.

In the yellow pages you will see plenty of offbeat degrees tossed around. Although Ph.D. (doctor of philosophy) is the only legitimate doctorate degree for a psychologist, you will find such things as Ps.D. ("doctor of psychology"). Ms.D. ("doctor of metaphysics"), and L.L.B. (to be confused, apparently, with LL.B. — bachelor of laws).

The degree of Ph.D. is used in ways that cause suspicion, too. An East Coast operator a few years ago used the degrees M.A. and D.D. after his name and taught yoga. As styles changed, however, he quietly became a Ph.D. and offered to counsel all comers on "all problems."

Another danger in the yellow pages is the welter of scientific-sounding specialists. Just remember that psychologists practice only the recognized science in which they are trained. Very few use hypnotism or hypnotic suggestion, and at this stage in the use of that psychological tool, the safest thing to do is to steer clear of any hypnotherapists outside the control of a hospital or clinic.

The only psychologist practicing alone that you can be absolutely sure of by looking in the yellow pages, then, are those that have a Ph.D. after their names *and* a notation that they are diplomates (sometimes abbreviated to DPL) under the American Board of Examiners in Professional Psychology (often cut to ABEPP).

WHAT THE PHONIES ARE LIKE

A conservative view of what the psycho-quacks are like as compared with qualified psychologists is given in a study of twelve of them who practiced in Los Angeles.

Of the twelve, three had never had any university work at all; three had bachelor's degrees from accredited universities — but in history, fine arts and business administration, not psychology; and the other six had degrees from nonaccredited and highly suspect institutions.

Five had no postgraduate clinical training. The seven who had "internships" had taken them at nonstandard religious and scientific agencies.

When interviewed, half of the twelve said they felt no need for further training at all. One ambitious man said he wished he had a degree — in business administration.

Only four of the twelve practiced in office buildings of the type almost all qualified psychologists use. Six were in small private buildings, usually converted homes, and the others were in their own homes or a hotel. But they were not fly-by-nights. On the average they had practiced in Los Angeles for nine years. Most of them did well enough, too, to devote full time to their practice, although a couple augmented their incomes with lectures.

Typically, they were lone wolves, practicing alone and staying clear of others in the field. Typically, too, they reported they had no desire for interchanging ideas with colleagues.

None, of course, belonged to any recognized local or national association. Almost none read any regular professional journal.

Although qualified psychologists get most of their clients through M.D.'s, these twelve said most of theirs came from referrals by former or current patients. They treated all ages of people and had few restrictions on the type of mental difficulty they would treat. Five even said they would handle psychotics.

Also, as might be expected, the twelve unqualified practitioners "cured" their patients in less time and with visits at less frequent intervals than professional men require. About half said 6 months of once-a-week treatments did the trick. Legitimate psychologists usually see clients twice a week for 12 to 18 months.

Do the phonies ever help anyone? Strangely enough, they probably do occasionally. It is as a prominent psychologist once said, "The darndest things help people."

HOW TO FIND A GOOD PSYCHOLOGIST

Among reputable men, you have two choices — those in private practice and those in psychological clinics. At clinics, usually in hospitals, schools or family-service centers, you get the benefit of a whole team of experts for maximum safety, and generally the cost is lower. A warmer, closer relationship can often be built up, however, outside clinics. If you do wish to go to a man in private practice, pick a diplomate in clinical psychology.

To find a clinic, ask at the psychology department of the nearest university, at your local public health department or at the social welfare office. Or consult the directory of your state psychological association. National directories of qualified people can also be found at libraries.

Finally, once again, don't depend on the telephone company's yellow pages. As one psychologist complained: "We still need to find a way to move most of the listings from *P* for *psychologist* to *Q* for *quack*."

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Four Great Lacks in Mental Health

OREN ROOT

Mental illness is one of the most serious social problems of our day. Psychologists have joined psychiatrists and psychiatric social workers to form a cooperative team, a pooling of talents, skills, and experience to provide the best possible attack on the problem. Psychologists' contributions include research, diagnostic procedures, psychotherapy, and training of personnel. Of these, perhaps research is the most important, because, as Root points out, there is so much we do not yet understand about behavior pathology. We have not completely lifted the aura of mysticism and social stigma so long attached to it. We have learned a great deal about mental illness in a short time, but much remains to be learned, and the "four great lacks" Mr. Root describes must be satisfied before we can deal effectively with the problem.

Mr. Root is a lawyer practicing in New York City. He has accepted leadership in several welfare projects, including the presidency of the National Association of Mental Health in 1950–1952. The selection that follows was published in the *New York Times Magazine* of May 4, 1952 (pp. 11; 31–33). It is reprinted by permission of the publisher and the author.

Nearly half a century has passed since Clifford Beers wrote "A Mind That Found Itself," his autobiographical account of conditions in the mental hospitals of his day. In the years since then much has been done to improve the state of affairs about which Beers wrote. Yet, for all the very real progress, the problem of mental illness remains one of the outstanding problems of our age. This is so whether one regards it from the standpoint of the suffering of the individuals concerned, of the effect of mental illness upon our whole society, or of the dollar cost of caring for the institutionalized mentally ill.

The facts are appalling. Unless something is done to prevent it, one out of every twelve children born in the United States this year will at some time in the course of life suffer a severe mental illness — an illness severe enough to justify hospitalization. Nearly half of the persons in hospitals in the United States today are mental patients. Even among those in hospitals who are not designated as mental patients there is a startlingly high percentage (the estimate ranges from 25 to 50 per cent) whose illnesses have important psychiatric complications. During World War II more than a million registrants were rejected by Selective Service because of mental and emotional disorders, and nearly half a million more were discharged for the same reasons after having been accepted.

But the institutionalized mentally ill and those who were rejected by Selective Service are only a fraction of those with some sort of mental or emotional disturbance. Reasonable estimates of the total run as high as 9 million. This number includes the problem drinkers, of whom there are estimated to be nearly 4 million, three-quarters of a million of these being chronic alcoholics. It includes a good share of the 50,000 persons who are addicted to narcotics, and of the 275,000 children under 17 who are brought into juvenile courts each year. It includes the 17,000 Americans who, in an average year, commit suicide. And finally it accounts for a substantial part of the divorces (one for every four marriages), of absenteeism and accident proneness in industry, and of crime.

Plainly, this is a problem of fearful dimensions. To the question of what is being done about it, the answer must be: Much — but not anywhere near enough. The job of doing something effective is plagued by four great lacks: lack of adequate facilities; lack of trained personnel; lack of fundamental scientific knowledge, and lack of public understanding. Let us consider each of these in turn, then the measures necessary to remedy them.

THE LACKS

1. Lack of Adequate Facilities

Eighty-two per cent of all mental hospital beds in the United States are in institutions operated by state governments. Although there are some notable exceptions, by and large they are overcrowded, understaffed, financially starved, and physically obsolete. Treatment — as opposed to mere custody — is available only in limited degree, and to many patients not at all. The average sum available to maintain a patient in state mental hospitals is $2.04 a day, compared to $10 in private psychiatric hospitals and $7 to $10 in general hospitals. The American Psychiatric Association's minimum standard, now outdated by inflation, is $5 a day.

An inevitable consequence of all this is that only in a small percentage of cases is any real effort made to bring about recovery. The others — the senile, the "chronic" patients — are often housed in some remote and dilapidated structure where they are fortunate to see a doctor occasionally passing through the corridors. The final consequence is that the average person entering a state mental hospital today has only a 40 per cent chance of recovery or significant improvement.

The lack of adequate facilities for psychiatric treatment includes also, it should be said, a comparable shortage of clinics; of psychiatric services in general hospitals; and of various forms of psychiatric aid in schools, in connection with courts (especially juvenile and domestic relations courts) and elsewhere. All these services are necessary to the all-important task of insuring people against having to go to mental hospitals in the first place. Clearly, large as it is, the more than $600,000,000 a year spent in support of public mental health facilities in the United States is not enough.

2. Lack of Trained Personnel

Money alone is never sufficient to cope with problems which are as large and complex as that of mental health. Even if funds were forthcoming to build all needed facilities, personnel to man them still would not be available. There are about 6,000 psychiatrists in the United States today; to meet the minimum staffing requirements of present psychiatric facilities would require 14,000, and if psychiatric services were extended to meet the real needs of the people, the number of personnel required would be far greater — requiring a tremendous expansion in present-day opportunities for training them.

This problem — which applies not only to psychiatrists but to psychologists, psychiatric social workers, psychiatric nurses and ward attendants as well — is closely entwined with that of the first: lack of adequate facilities. For the hospitals themselves should be among the most important training centers. And, as we have seen, one reason that they are not is that most mental hospitals are so isolated, unprogressive and poorly financed that they cannot attract and hold personnel required either to train or be trained.

3. Lack of Fundamental Scientific Knowledge

This great lack points up a crucial but little-recognized fact. It is true that even the knowledge presently available, if effectively put to work, would greatly improve the situation. But it is equally true that existing knowledge is too small by comparison with the magnitude of the problem.

Schizophrenia and the psychoses of old age, for example, between them constitute half of all new cases of mental illness requiring hospitalization each year, yet far too little is known about the causes of these diseases, and even where treatment is successful there is inadequate understanding as to why this is so. The country which spends more than $600 millions per year in tax money alone to provide custody and care for the mentally ill spends only $5 millions per year in *aggregate* public and private funds on research to discover how to prevent and cure mental diseases.

If the same amount of research money were to be spent per patient under treatment for mental illness as is spent per patient under treatment for polio, cancer or heart disease, the sum would be $30 millions per year. Even this sum would not be large by comparison to the $1 billion spent annually on all scientific research.

4. Lack of Public Understanding

This, the last, is the most serious of all our deficiencies in the treatment of mental illness. For while much progress has been made in educating the American people to the nature and scope of the mental disease problem, by and large we still tend to regard psychiatric illnesses as something to be ashamed of; and largely because of this fact most of us still have no inkling of how grave the menace is.

The problem here, clearly, is to bring the whole subject out from the cobwebs and from under the beds where it has reposed for so many centuries into the light of day where it can be looked at and discussed openly and fearlessly. This is precisely what has been done with respect to tuberculosis and cancer. That these diseases can now be freely discussed, without any of the foolish feeling of shame or dishonor which formerly were associated with them, is due in very large part to the campaigns which have been conducted by informed and aroused individuals over the last fifty years; while the advances made in controlling these diseases are in turn due, in very large part, to this achievement in public education. Until the same can be achieved in the mental health field, no significant progress will be made.

THE REMEDY

All the deficiencies described above stem from, and in turn act upon, one another; and for this reason we must recognize that very little progress can be made in terms of any particular facet of the problem except as it is made in terms of all the others.

For example, any effort to improve treatment facilities in mental hospitals runs at once into the lack of properly trained personnel to staff the hospitals. Such specialists, as we have seen, are not available — for one reason — because the hospitals are ill equipped to serve as training centers; and this condition is the result in large part of bad governmental administration and inadequate legislative appropriations, which in their turn arise out of the apathy and ignorance of the electorate.

It is the same with the all-important question of psychiatric research. Research requires physical facilities; it requires trained personnel; it requires financing. Yet the existence of a good research program is one of the factors which attract the personnel and justify the physical facilities. And facilities, personnel and financing are all dependent in the last analysis on the values put upon them by the public and the leaders of public opinion.

Thus we see that though the specific remedies are (1) more money, (2) a broader and more effective program for training psychiatric specialists, and (3) greater emphasis on studying the causes and cure of mental disease, underlying them all is the need for arousing public determination to take action toward these ends.

It is this task to which increasing numbers of individuals and organizations concerned with promoting the mental health of the nation must dedicate themselves. Their job — and the job of as many American citizens as can be enlisted — must be to encourage appropriate officials and agencies in the kind of action which will overcome the deficiencies in facilities, personnel and research work described above.

Since so large a part of all mental health facilities are Government-controlled, a considerable measure of the work must take the form of addressing the attention of Government officials, both executive and legislative, to the need for action. But Government officials are not by any means the only objects of their encouragement. A large part of their activities must be directed at urging newspapers, magazines and broadcasting companies to engage in more and better educational projects in the mental health field. Campaigns must, as in the past, be focused on parent-teacher associations, on church and other groups, through whom the principles of mental health can be introduced into the training of teachers, clergymen and other professionals whose duties bring them into contact with large numbers of people.

And finally — and most important — these citizens' activities must be aimed at the citizens themselves. Various governmental and private bodies can appropriate funds to provide for better facilities, devoted scientists can develop improved methods of care and treatment, but only the people can change the fundamental personal and community attitudes which surround the subject of mental illness. In free and democratic societies, where the people are the sovereign power, they must also acknowledge ultimate responsibility — and so it is here.

It should be pointed out that the picture is far from entirely black. For all the tremendous problems which remain, the combined efforts of the Government, the psychiatric associations and aroused citizens have brought about very real progress, which can by no means be overlooked.

In the years since Clifford Beers wrote, we have seen the development of electric shock and insulin shock, of psychoanalysis and of group therapy. We have witnessed an entirely new accent on the theory of "preventive" mental health, with special regard to the needs of children and the functions of parents. While the conditions in mental hospitals are in some cases still scandalous, in other cases records have been made which inspire hope and encouragement for the future. And, most significant of all, public awareness of the problem and of its importance is growing all the time.

All in all the mental health picture in the United States can be a cause for optimism or despair depending in large part upon the attitude of the person considering it. If one looks just at the statistics, at the number of mental patients and the paucity of facilities and personnel, one can indeed fear for the future of the country, if not of the human race itself.

If, on the other hand, one looks at the enormous and increasing efforts which are being exerted to combat the problem, if one looks at the record of progress in the last half century, and above all, if one believes in man's capacity to solve his problems when he confronts them squarely, then there is certainly room for hope and perhaps even for a calculated judgment that this problem will be solved as others equally difficult have been solved in the past.

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Riggs: Where Psychiatrists Learn

MARYA MANNES

The Austen Riggs Center described in this article is not, alas, a typical institution for the care of those who are mentally disturbed. Only a very small number of patients can hope to receive the kind of treatment available at Riggs. In hospitals, medical schools, and psychological laboratories all over the country research is being carried out to learn more about how to control mental illness, but only in rare instances, as at Riggs, is there such concentration of effort. Research has progressed to the point where it is evident that some control is possible, but much more is necessary. The doctors on the Riggs team include MD's (psychiatrists) and PhD's (psychologists) whose methods of learning to control deviant behavior are reported here.

Marya Mannes is a professional journalist and author. Her article on Riggs appeared in the *Reporter* of November 4, 1954 (pp. 35–39), and is reprinted by permission of the publisher.

The house where the patients live is called the Inn: a white building, unpretentious but formal, too large for a private residence nowadays, too small for a hotel, in no way an institution. For the basic tenet of the Austen Riggs Center is that the best way to care for the sick in mind is to keep them, insofar as it is possible, among the healthy, as a part of a living community to which they must try to relate themselves sooner or later. It is an "open" sanitarium, set back from the broad and leafy main street of Stockbridge, Massachusetts; and at this season particularly, the American dignity of this Berkshire town and the extraordinary beauty of the autumn-flaming trees made one think that simply being there was a kind of therapy in itself.

Forty patients live in the Inn, each suffering from a different kind of psychoneurosis. They are not sick enough for a "closed" institution, but they are too sick to continue their ordinary lives while they are treated. They range from the teens to middle age, with the majority in their twenties and thirties.

About three-fourths of them are able to pay twenty to twenty-nine dollars a day for room and board and twenty dollars a day for their hour with the psychiatrist. The rest are substantially aided by grants. All live most comfortably, in interiors of space and charm: cheerful, light bedrooms; an enormous yet friendly living room; a dining room furnished and flower-set as in a resort inn. Under the supervision of seven nurses, never in uniform, the patients may come and go as they wish, and at mealtime they may sit where they wish at the various tables. They are treated by ten psychiatrists and psychologists.

Who are these forty? They cannot be named, of course, or described. They might include a cousin of yours, or the nephew of a friend, or a patient of your doctor's, or you. For one of the most disturbing facts of today is that there is almost no one of us who has not, in the course of a lifetime, confronted mental illness, either directly or indirectly. The mentally ill occupy over fifty per cent of the hospital beds in the nation. If we do not know any of the hospitalized, then out of the eight or nine millions of mentally ill among us we know at least one person who has stepped over that faint and wavering line between reason and irrationality, between balance and imbalance, between trouble and torture. It is out of these that the forty at Riggs are chosen.

Even if you saw them among you, as the natives of Stockbridge do, day in and day out, you would probably not recognize them as having crossed this line. Only the trained eye and the intuitive heart can single out the disturbed, can detect, through a way of walking or using the hands, through expressions of the eyes and mouth, which of us are trapped in a private prison. Without this insight, they are as you or I.

Yet how, the outsider asks, do these forty out of nine million manage to get this kind of attention? Who are the lucky ones? The reason cannot be money, for if such care were everywhere available, there would be thousands able to pay for it. As for types of mental illnesses, Riggs appears to set no requirements except that the patient be controllable in relation to others and yet sufficiently disturbed to be beyond the reach of ordinary outpatient therapy. To select those forty who should be admitted out of this great intermediate mass of the mentally sick referred to Riggs by doctors and other institutions is one of the staff's toughest problems. Even after the prolonged and exhaustive study of case histories that precedes final admission, mistakes can be made. The patient may become uncontrollable and must be referred to a closed institution, or may be found so unresponsive to treatment that it is useless for him to stay on. The doctors can never be sure because they do not know enough.

THE PAINFUL VOYAGE BACK

The whole purpose of the Center is just this: to learn. Riggs is a pilot plant, a sort of institute of advanced study where some of the best psychiatrists in the country have the means, the time, and the privacy to find out what sickens the human mind and what can restore it. This is virtually impossible in a state institution, where one doctor must often "handle" four hundred patients. At Riggs there are four patients to one doctor. "The ratio of four hundred to one," said one psychiatrist there, "is custody. Four to one is treatment."

Schizophrenia — anxiety — paranoia — fear — apathy — aggression — masochism — what can they mean, where do they start? The woman who flies from marriage into unreality, the brilliant youth who breaks down on the threshold of a successful career, the spinster who searches forever for a home she has never had, the husband who after ten years of happy marriage feels an anguished compulsion to dress like a woman, the young girl who craves death, the woman who washes her hands all day and can touch nothing for fear of defilement — these were once able to live with themselves and with others, if not happily, then at least within the pattern of society. What pushed them out of this pattern — beyond the line?

To know this is to know the individual. And five days of every week each patient at the Inn walks down the spacious main street of Stockbridge to undertake the painful voyage of discovery which is knowledge of self. The patient walks to a small white building, Purinton House, where the doctors have their offices, and for an hour, which may be infinity, speaks out of his personal darkness. The doctor listens, guides, probes, and tries — with all the knowledge of human pain he has acquired — to understand. For that is above all what these people need: to be understood; and even more, to understand themselves. It may take months or years, but not until they do understand have they made the trip back to reality.

"If we can help them retrace their steps," the psychiatrist says, "we can show them why they took the path they did and where it has led."

The doctors talk with humility before such mysteries. "We think we know some of the reasons, and we know some ways to help. The rest is unexplored territory which we must penetrate with every resource we have. The trouble is, people expect 'results,' as one would in an operation. They expect 'cures.' But we don't even use the word. It's simply not applicable. Even though a patient may leave us much better than he came, though he may have 'social recovery' — the ability to function in everyday life — how can we tell he is wholly cured? We can only say that he is 'markedly improved' or 'restored to his premorbid condition.' But we can never be sure that under stress the wounds will not open again."

The doctors of the Austen Riggs Center are a notable group: Dr. Robert P. Knight, formerly chief of staff of the Menninger Foundation in Topeka; Dr. Edgerton Howard; Dr. David Rapaport, former director of research at Menninger; Dr. Margaret Brenman, former director of the department of psychology at Menninger; Dr. Stuart C. Miller; Dr. Robert B. White; Dr. Joseph Chassell, formerly chief of psychotherapy at the Sheppard and Enoch Pratt Hospital; and Professor Erik H. Erikson, formerly professor of psychology at the University of California and president of both the San Francisco Psychoanalytical Society and Institute. Supplementing these doctors are several young Fellows in psychiatry who are receiving their advanced training at Riggs.

Formidable though it may sound, the staff of Riggs is a relaxed and personable group, free of pretension. Dr. Knight is a huge man, mooselike, six foot five, who can speak simply on complex matters. Dr. Erikson is a big, rosy-cheeked, white-haired, blue-eyed Dane: a Viking and — if there ever was one — a well-cast "father image." Dr. Brenman, small, dark, and highly articulate, is the wife of William Gibson, author of *Cobweb*, the recent novel about the mentally ill, and mother of a small son who will most certainly not suffer from rejection. She is warm and earthy and does not brandish the knowledge she has managed to assemble and dispense in her thirty-three years. Dr. Chassell, pipe in mouth and humor in hand, could be an urbane professor of history. It is easily understandable why such men and women are able to help other human beings and are well equipped to turn experience into wisdom.

OPEN HOUSE

In full consistency with the tenet of the "open" sanitarium held by the Riggs staff, on one weekend each year the doctors, the trustees, and a few invited guests join in a series of meetings dedicated to bridging the gap between the intuitive layman and the practiced professional in a field which is of acute concern to both.

It is also consistent with Riggs that most of its trustees are younger than most, in their forties or early fifties. Among them are bankers and lawyers of substance and acumen, with alert and attractive wives; a nationally known political columnist; a successful TV and documentary scriptwriter; a distinguished woman portrait painter. Their common denominators — infrequent among boards of trustees — are vigor and vision.

Of the guests invited, some were interested friends of Riggs, some were writers. We were free to ask questions about the work at Riggs, and we did.

This freedom had, to be sure, its limitations. Professional ethics forbade discussion of specific cases, and only those problems and types of mental illness were described which, through their frequency of incidence, could refer to many and not to one identifiable person. Thus the questions had to be general in an area where generalities are particularly misleading, for no psychiatrist can automatically apply to one patient what he has learned from another. Each mind is a private world, although the winds that sweep through them may be universal.

So the doctors spoke of their work and of tentative conclusions, reached not only at Riggs but in other centers of study in the country — the Menninger Clinic, Chestnut Lodge, the great universities.

The doctors know that when people reach the breaking point or exceed it, they need — as Professor Erikson calls it — a moratorium: a vacation from their former activities and environment. This may be as short as a month or as long as two years, but without this pause the sickness can only feed and grow on itself.

The doctors know that with all its dangers and disadvantages the "open" sanitarium is the best for certain types and stages of illness. This freedom imposes a far greater strain on the staff — and in some ways on the patient — than confinement would, but without it the return to reality becomes progressively harder. Rigid routine and supervision atrophy the will, and the will must reassert itself for eventual health. The patient, the doctors feel, must at no time be entirely divorced from the external world.

THERE MUST BE INVOLVEMENT

They know now that belonging to a group is much better for this type of patient than isolation. The patients at Riggs have a kind of self-government that expresses itself in regular meetings to decide questions ranging from food and art exhibitions to the expulsion of a patient whom the majority feel dangerous to their welfare. Being part of an organization gives them an insight into others and into themselves which is a prerequisite of health. This, the doctors maintain, more than compensates for whatever friction and disturbance may (and does) rise from close contact between highly strung withdrawn or aggressive people. This friction is, after all, part of life.

The doctors know that "occupational therapy," heavily relied on for years, is not enough. To weave baskets or make belts may pass the long hours and temporarily relieve tensions, but occupation is valueless without involvement. The patient must in some way fulfill and express himself in work, and this is what Riggs is trying to do for him in its group activities program.

Under the direction of Professor Erikson's wife Joan, a woman of remarkable balance and insight, and under professional instruction, the patients produce paintings and sculpture which, apart from illuminating their condition, can stand comparison with some of the work seen in contemporary galleries, and photography of artistic and technical merit. They produce and act in plays before paying local audiences with a competence which, according to Clifford Odets, who saw one of his plays so performed in Stockbridge, is equal to that of any good amateur group: no more than the usual nerves, no more than the usual "fluffs." This ability of the emotionally disturbed to rise to crisis and accept responsibility has amazed even their doctors, although one of them remarked ruefully, "I was very upset when one of my patients, after doing a fine job in a play, went back to the Inn and tried to set fire to it."

Yet this was an exception. To many of the Riggs patients, creative experience brings, in Mrs. Erikson's words, "the kind of enrichment they can take away with them." It feeds that emotional starvation — the corollary, it seems, of a mechanized society — which is at the root of so much suffering.

SOME HARD QUESTIONS

Questions lingered in the air long after the meeting:

There was talk of a man who was incapable of responding to therapy because he had no "conscience." What was conscience?

Was not the Inn a sort of perfect life in its freedom from responsibility, its comfort, its lack of pressures and disciplines — and therefore an unreal one? Was it not true that some patients, who had "never had it so good" in their starved or burdened lives, spent the rest of their days yearning for Riggs, the ultimate haven? And was this a help or a hindrance to their readjustment to the harsher realities?

Why did more and more of the young show need of psychiatric help? Did this not show a lack of communication with older and wiser beings — either parent or teacher or priest or friend?

What part did heredity play in mental illness? The doctors maintained that it was very slight compared to environmental factors, yet did not the constitutional factors in each human being affect environment?

Was not the psychiatrist, in his justifiable impatience with the questionable concept of "normality," in danger of directing his sympathy to the abnormal, accepting it as the natural product of our times? Compassion for the sick, without which admittedly no treatment is possible, was infinitely desirable as compared to former attitudes of aversion and judgment. Yet was not the tendency to exempt the sick from responsibility, laying it at the feet of society, too pronounced?

On the defensive after long popular suspicion and misinterpretation, was not psychiatry becoming a kind of religion, with the doctors as priests, the patients as disciples, and the world outside — the world of the so-called "normal" or balanced — an obtuse and unenlightened one? And in spite of the need in each profession for special terms and definitions, did not the highly technical language of psychiatry serve to heighten this defensive wall?

These were some of the questions the visitors asked the doctors, who may indeed have found them primitive, banal, and predicated on ignorance. It is to the credit of the Riggs staff that they tried to answer them without impatience, or condescension, realizing perhaps that even in their oversimplification they were questions of legitimate concern to a great many people.

They touched, also, on legitimate and urgent areas of research, for which a center like Riggs is an ideal laboratory. For while its immediate aim is to ease and if possible dispel the mental anguish of the patients in its care, the long-range goal is to isolate the sources of this cancer of the soul and, having located them, to treat, alleviate, or eradicate them.

One young doctor said it best: "If we can change neurotic suffering into common unhappiness, we feel we have accomplished a great deal."

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The Air-Conditioned Conscience

FREDRIC WERTHAM

In this selection a psychiatrist speaks out about the "do-it-yourself" books through which normal people can, allegedly, solve their personal and emotional problems. Although Dr. Wertham's criticism of the self-help literature is rather caustic, he believes that it is justified. It is not only the severely disturbed who need professional counseling. Practically all of us at some time in our lives encounter problems which we cannot see clearly or objectively and can scarcely hope to solve through self-reassurance and inspiration literature. Wertham's point, which could also be applied as a criticism of most of the popular self-help columns in the newspapers, is that really successful personal adjustment comes not from the "sweeping solace" offered by this literature but through examination, on an individual basis, of a person's total life situation.

Dr. Wertham is a practicing psychiatrist in New York City. He has been associated with several of the hospitals there and is well known as a consultant, writer, and interpreter of psychiatric problems. The selection that follows appeared in the October 1, 1949, issue of the *Saturday Review of Literature* (pp. 6–8; 26–27). Copyright, 1949, by Fredric Wertham. Reprinted by permission of James Brown Associates.

There exists right now a flourishing literature which for brevity and from its star example may be called peace-of-mind literature. These peace-of-mind books have not been studied as a group before. To lump them all together may be unfair to some individual book, and may not be quite scientific. But although there are no sharp boundaries, it is a group readily identified and with many common features. They are all "How To" books: How to Use Psychiatric Principles to Become a "Cock-Eyed Optimist."

Nothing will give you more quickly a picture of this whole literature than a look at some of the titles: "Let's Explore Your Mind," "Emotional Security," "Chart for Happiness," "The Complete Life," "Managing Your Mind," "Emotional Hygiene," "The Comforts of Unreason," "Making Our Minds Behave," "How to Psychoanalyze Yourself," "Personal Mental Hygiene," "Peace of Mind," "Peace of Soul," "Emotional Maturity," "On Being a Real Person," "How Sane Are You?" "How to Think Straight," "How Never to Be Tired," "How to Remember," "Mastering Your Nerves," "How to Stop Worrying and Start Living," "Life Is for Living," "Self-Analysis," "A Guide to Confident Living," "The Mature Mind," "Living Wisely and Well," "Psychiatry for Everyman," "Psychiatry for You," "And

We Are Whole Again," "What Your Dreams Mean," "How to Think About Ourselves," "Understandable Psychiatry," "The Mind in Action," "Be Glad You're Neurotic," "Emotional Problems of Living," "Release from Nervous Tension," "How to Conquer Your Handicaps," "Make Up Your Mind," "Don't Be Afraid," "How to Get Rid of Fear and Fatigue," etc.

Roughly, these books can be divided into three categories. The first are the how-to-do-anything books or how-to-be-happy books based primarily on faith in oneself. They imply that anyone can do anything or be anyone. They seem to say that you can be transformed into a Tarzan or an Einstein if only you go about it in the right way and are persistent enough. In the second group are those offering similar help on the basis of faith in psychiatry. And in the third group the emphasis is on faith in religion — made more intriguing by psychoanalytic overtones, either consonant or dissonant.

The existence and wide popularity of these books raises a number of problems. There can be little doubt that the vogue of such self-improvement books indicates that there are lots of troubled people who need what these books promise — or think they need it. Since psychotherapy is restricted mostly to the well-to-do, the upper classes, and those who need it least, many people evidently seek from books what they cannot get otherwise. What is the significance of this sort of book in terms of general mental health? And what do they mean in terms of the society that breeds and reads them?

I have asked many people which of these books they have read and what they got out of them. In many instances I have tried to evaluate their effect objectively. There is no doubt that quite a number of these books contain grains of common sense and sensible statements of psychiatric observations which may sometimes be of some help, or at least give the illusion of helping. They have influence because they seem to be disinterested and objective, and because they carry the authority of the printed word plus the authority of the scientific foundations they claim to have.

One of the most typical replies I received was this: "I liked especially the case histories. A man got helped and I said to myself, why can't I help myself. It made me feel better to read that people can come out of all their troubles." That is, of course, a good attitude for people to take. The only question is, as Napoleon said, what did you do the next day? As another man told me, "I felt better after reading that book. But the next time it just didn't ring the bell."

A very decent and most harassed young woman told me: "I like these books. They foster understanding for self-discipline for two people to live together, let alone all society. They show that the same mechanism operates in religion and in psychiatry — both in the spiritual realm beyond material reward. They make you self-sufficient and give you inner peace. They give you the reasonable satisfaction which one needs to have if one wants to remain sane."

This answer illustrates the sweeping solace these books give on a theoretical plane, which is really a plane of unreality. For they are addressed to anyone or everyone and take no cognizance of individual differences. The readers are people who consciously or unconsciously reach out for guidance, help, and strength. They think they are getting individual understanding when what they really receive is generalized consolation. They don't like the rules by which their ordinary life must be lived, so they enjoy reading about rules which they would like to live by but don't have to. Whatever their own problem, they read avidly in these books that other people have the same problem. Not having the discipline of scientific clinical observation, they see themselves in any case history or any generalization. They find their fears about the present, and the future particularly, relieved, for as one man told me, "There was something in your childhood that causes all that, and that is the only thing that is wrong — and after I had read that I had peace of mind for twenty-four hours."

There, of course, is the rub. For many of these readers will fall victim to the implied threat that — as in the comic-book story of Dr. Sigmund Adler — they are "too far gone" and had better hurry to the nearest psychoanalyst. If advertising ever existed, this literature is it. As if in this day and age, when mental-hygiene clinics have waiting lists filled up for a year in advance, people still need to be "enlightened" in this respect! The trouble is that while the reader has the illusion that he is being directly and personally talked to he may be given all kinds of misinformation as if it were proven fact. In one of the recent articles which are miniatures of this kind of literature the writer (who is identified as the wife of an "eminent psychoanalyst") gives the shocking misinformation that electric-shock therapy is a good test to determine whether you are mentally disturbed or not! A similar article contains this misinformation: "The patient must spend an hour a day with the doctor for a period of perhaps one to five years, and the cost may range from $1,000 to $25,000. Anyone offering a much quicker or cheaper psychoanalysis, except as charity, may safely be labeled a quack."

Where these books deal with sex they commendably alleviate fears about perversions — while at the same time, however, describing them just in case you should not know them yet.

There is no doubt that many people have enlarged their vocabulary through this sort of reading. They have gained a surface understanding of deep psychology and learned a lot of new glib words, which are especially useful in social conversation if the other person doesn't know them yet. The difficulty is that a whole barbaric vocabulary has crept not only into conversation but also into literary writing: "ego strength," "return to the womb," and many other such expressions. When recently a pocket edition of "Manhattan Transfer" was published some people took it for granted that it was a book about psychoanalysis in New York. Psychoanalysis has reached into the psychotheological books, too. And you can find in them such strained expressions as "souls stretched out on psychoanalytic couches."

But this is not just a question of words. More and more people are using psychoanalytic terminology not as a tool but as a substitute for thinking. Recently a judge sentenced an eighteen-year-old youth to death, disregarding the jury's recommendation of clemency. He stated that he based himself on the probation report which said of the defendant: "His personality is permeated with psychosexual habits of thought and conduct." What would the judge think if he learned that he also (and all other human beings) is "permeated with psychosexual" thoughts?

One attraction of these books is that they give simple, pat answers. Linking science, common sense, and spirituality, many of them do not leave out the material side of things. They talk about security, especially emotional security; but financial securities hover in the background. They seem to imply that the end justifies the means — if you have the means. And since they have to be best sellers a good title for some of them would be "The Bacon and I."

As for teaching how to get on with other people, they preach a kind of Machiavellianism not for princes but for the little man. Somehow these books convey the idea that you can be selfish with justification as long as you make yourself feel that you are unselfish; that you can enrich yourself at the expense of others as long as you persuade yourself that you only give "service" to them. In your personal relations you are taught to be cunning and diplomatic — all, of course, on the basis of psychology. And since you should not feel guilty, you certainly are not supposed to feel guilty about the insincerity entailed in all this. Recently I examined a man who seemed to me to have mastered the art of "using psychology" as taught in this literature to perfection. He won the confidence of many lonely women and certainly influenced them. (The complication was that he took their money and, when the "psychology" didn't work any more, killed a few of them.)

All these books breathe an atmosphere of optimism. Everybody can be happy or should be happy and if he *isn't* happy he should be happy that he isn't happy. This attitude seems to have spread even to one of our biggest universities, which recently announced a "Project Concerned with the Cheerful Aspects of Human Behavior. The subjects will not be the mentally distressed, but the strikingly happy and successful persons. Through detailed and intensive study of these individuals it is hoped that light will be thrown on the factors essential to effective and happy living." (Cost: $54,000.)

This optimism is different from the simple kind found in the old new-thought and uplift literature. It exists against a background of anxiety and evoked hypochondriasis. As a matter of fact, the negative emotional reactions aroused by this literature consist in a new kind of mental hypochondriasis which is a mixture between the cure and the disease. People have commented that in "Death of a Salesman" we never learn what Willy Loman is selling. But it is easy to guess what kind of books he reads — the peace-of-mind literature with the optimism of which life catches up in the end. What these books do *not* teach is to face life as it is. They are like tax guides which teach us not how to pay but how to evade taxes.

Books like "Peace of Mind," which seek most thoroughly to blend psychoanalysis and religion, work in the suggestive twilight of abnormal psychology and supernatural revelation. It is not quite clear whether they smuggle psychoanalysis into religion or religion into psychoanalysis. The parallel between psychoanalysis and religion is, as Freud pointed out, a false one. The road to Damascus is not the road to Vienna. Even the road to Bollingen is a thing for itself.

The outstanding feature common to these

books is that they seem to be addressed to individuals who live mostly in a social vacuum. The influence of the environment in producing worry, tension, or anxiety is either completely disregarded or accepted as inevitable. There are no social forces, no social history, no social interaction, no social responsibility. In one of the most successful recent books an untrue statement about Negroes is repeated as if it were scientific fact: They don't "have the kind of heart disease brought on by worry because they take things calmly." Social evils are rationalized and therefore justified as the result of individual faults amenable to self-improvement or psychoanalytic or psychotheological influence. The lesson is, clearly, that it is not the social scene but its isolated inhabitant that needs to be analyzed. Repressive measures of governments do not exist; there are only repressing mechanisms in the mind of the individual. If you can't help yourself the remedy you seek must be individual, not social. Instead of fighting against such attacks on civil liberties as "guilt by association," you should lie on psychoanalytic couches and ruminate about guilt by free association. Among all the case histories in this literature, there is no suggestion that there are maladies which as Dostoievsky said "arise from the abnormal conditions of society." There is almost no awareness of society's responsibility toward old, infirm, sick, and handicapped people — not to mention the normal ones.

Is there anything new in this literature? I think there is. It is, of course, a type of escape literature. It will not help you in the long run to an escape from anxiety, from suffering, or from doubts. But it does go a long way to help you to an escape from social responsibility. One can extract from these books a new concept, never before so fully elaborated — the concept of an air-conditioned conscience.

SUGGESTIONS FOR FURTHER READING

Brunswik, Egon. The probability point of view. *Psychological Review*, 1943, *50*, 255–272. The author believes that psychology must be satisfied with probability predictions of a low degree of exactitude. This article and the one listed below by Hull were originally presented on a symposium on scientific method.

Carnap, R. What is probability? *Scientific American*, September, 1953, pp. 128–138. Two kinds of probability are described — statistical and judgmental — which may be involved in "if-then" situations.

Cronbach, L. J. *Educational Psychology*. New York: Harcourt, Brace, 1954. One of several good texts which shows the application of psychological principles to the control of learning in the classroom.

Fryer, D. H., and E. R. Henry (eds.). *Handbook of Applied Psychology*. New York: Rinehart, 1950. Applications of research findings to the control of practical problems are shown in the 115 articles included in this two-volume handbook.

Gray, J. S. *Psychology in Industry*. New York: McGraw-Hill, 1952. A representative text showing how psychologists help control efficiency in industry.

Hull, Clark L. The uniformity point of view. *Psychological Review*, 1943, *50*, 273–291. In contrast to Brunswik, Hull believes that psychological laws may be as exactly stated as are physical laws, but that there are more restrictive limiting factors. Both papers are reprinted in M. H. Marx. *Psychological Theory*. New York: Macmillan, 1951.

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